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REPORT OF THE DEFENSE SCIENCE BOARD TASK FORCE ON UNIVERSITY RE--ETC(U)
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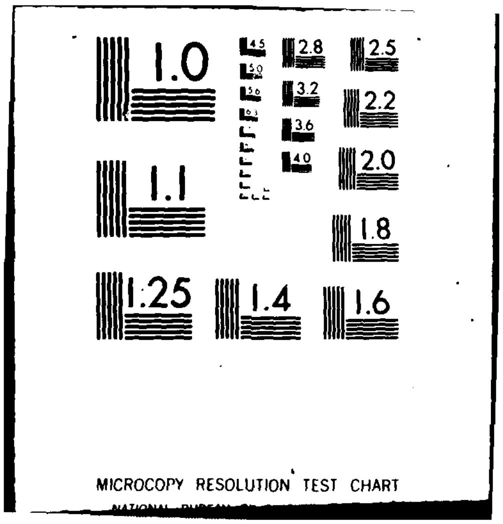
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Report of the Defense Science Board Task Force on University Responsiveness to National Security Requirements

January 1982

Office of the Under Secretary of Defense
for Research and Engineering
Washington D.C. 20301

Report of the Defense Science Board Task Force on University Responsiveness to National Security Requirements

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DEFENSE SCIENCE
BOARD

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

28 January 1982

MEMORANDUM FOR THE SECRETARY OF DEFENSE
DEPUTY SECRETARY OF DEFENSE
CHAIRMAN, JOINT CHIEFS OF STAFF

THROUGH: UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

SUBJECT: Report of Defense Science Board Task Force on University Responsiveness to National Security Requirements

The attached final report by the Defense Science Board Task Force on University Responsiveness to National Security Requirements was prepared under the chairmanship of Dr. Ivan Bennett. The report was prepared as a coordinated response to a House Armed Services Committee's request. The study addresses the following issues: Are the universities interested in and able to support national security requirements in both manpower training and basic research? Are current DoD contracting procedures appropriate, and what role should DoD play with other agencies like the National Science Foundation in support of basic research? What impact does implementation of export controls have on the conduct of research and teaching activities of the universities? What problems are caused by the high percentage of foreign nationals in science and engineering?

The principal findings of the study are that:

1. The universities are interested in improving their ability to support national defense needs but require sustained federal assistance to accomplish this, to replace obsolescent equipment, and to support graduate education of U.S. citizens by improved fellowship and educational support awards.

2. Science and engineering manpower needs can be met if the large numbers of students now enrolled in engineering programs are effectively trained and employed. Certain temporary problems, such as the shortfall in the number of PhD - level engineers needed for teaching, can be solved by judicious applications of resources.

3. Export control regulations continue to pose a problem for the university researcher, in part, because of the large uncertainty as to what is militarily sensitive. DoD can alleviate this problem by negotiating with university representatives a mutually acceptable set of guidelines for dissemination of research information considered sensitive. Publication of a new unclassified version of the Militarily Critical Technologies List would aid the process.

4. The large percentage of foreign nationals in graduate engineering programs is due in part to the decline in the number of U. S. citizens entering graduate schools. Appropriately targeted incentives such as increased stipends for U. S. citizens can reverse this trend.

5. A number of new DoD programs, some just beginning, could provide stimulus to an improved DoD/University relationship. These include increased 6.1 Research funding, apprenticeship programs, wider use of graduate fellowships and educational support awards, and the streamlining of contracting procedures.

The most time urgent problem is that dealing with export control, which has recently received high visibility. The university community is increasingly alarmed by the possibility of overreaction on the part of the Government in restricting the flow of scientific information, a vital part of the scientific enterprise.

You will find that this Task Force considered the issue of export control to be of major consequence, and dedicated a large part of the report to outlining a comprehensive program to solve the problem. I recommend that you review the Executive Summary.

Norm

Norman R. Augustine
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

DEFENSE SCIENCE BOARD

27 January 1982

Mr. Norman R. Augustine
Chairman
Defense Science Board
Room 3D1034, The Pentagon
Washington, D.C. 20301

Dear Norm:

Enclosed is the report of the Defense Science Board's Task Force on University Responsiveness to National Security Requirements. In preparing this report, we solicited and received a broad spectrum of opinion as to the causes of the problem and probable outcomes of any remedies we might suggest. As you can see from the list of presenters and attendees (Appendix B), we were able to reach a variety of individuals within the university community, including representatives from non-governmental organizations and associations affiliated with the universities. We also received important inputs from appropriate offices within the Department of Defense and the Military Services.

Our conclusions are encouraging. We found that there was indeed interest on the part of both DoD and the university community in restoring a healthier and more vital relationship for the support of national defense. That relationship has been eroded by a number of factors, not the least of which were the consequences of campus disruptions during the Vietnam era and the impact of the Mansfield Amendment on university defense research.

There are processes already in progress which are contributive to the restoration we all desire. DoD funding of university research is on the upswing; there are new initiatives such as the student apprenticeship program to foster interest in defense research; and the Services and OSD are putting more resources into graduate fellowships and other forms of educational assistance. The key to continuing success is long-term commitment. The "on-again, off-again" approach, characteristic of the past, will not work. Sustained, multi-year growth is required with emphasis in areas where there are clear deficiencies.

As highlighted in the Executive Summary, the manpower problem is serious but not as severe as we anticipated. There will be definite short-falls in certain disciplines, as documented in the report, but all in all, defense needs can be met if market forces work and the growing numbers of students enrolled in the nation's engineering programs are properly trained and employed.

DoD should take the initiative with other governmental and non-governmental organizations to remedy certain obvious deficiencies in the capability of the universities to train scientists and engineers. This includes the upgrading and modernization of research equipment and some programs to reverse the trend where graduate engineers are attracted away from teaching by more lucrative and satisfying careers in industry. There are over 2000 faculty positions vacant in engineering schools throughout the country.

The "foreign student problem" should be seen in the proper context. The high percentage of foreign students in graduate science and engineering programs (especially engineering) is partly the result of a decline in the number of U.S. citizens seeking graduate education. Bachelor level engineers, for example, are lured away from graduate school by high starting salaries in industry. This, however, may be a temporary phenomenon and, as our report points out, the trend can be reversed by proper use of incentives.

There are many benefits to be derived from the training of foreign students and these should not be lightly dismissed. The Task Force, however, recognizes that there are certain risks from a national security perspective if large numbers of defense research and development scientists are not U.S. citizens. There may be a need, however, to investigate more closely the security aspects involved in retaining some portion of these gifted foreign scientists and engineers, since they can and do make substantial contributions to the technology base in the United States.

Finally, the issue that greatly concerned this Task Force dealt with export control and the universities. This is a very sensitive area and one which must be approached with insight and understanding. Although, in our estimation, there is no easy solution, the process itself whereby DoD interacts with the universities to work out mutually acceptable terms for safeguarding critical information may be as important as any subsequent program.

Our report recommends a three-phase process whereby guidelines for the dissemination of technical information generated by the conduct of research would be developed. This could aid university investigators' discrimination between research that is essentially basic science and other research that may be significant from the point of view of product development or technology utilization, and thus, potentially subject to export control regulations.

In the first phase, DoD contracts for university research would be reviewed and guidelines developed for the dissemination of technical information. In the second and third phases, guidelines would be extended to other (non-DoD) federally-funded research and to non-federally-funded research if the need to do so is clearly established.

To summarize, we have found the universities willing and able to support the defense technology base with research and manpower training. For them to do so, however, will require certain specific actions as we have recommended in the report. We believe that it is important for DoD to undertake these initiatives soon, especially in the area of export control. The public at large and the university community in particular are becoming increasingly alarmed by the prospect of government overreaction which in the end may hurt the Department's chances of establishing a strong and healthy relationship with the universities.

Sincerely,

Ivan Bennett, Jr., MD

cc: E. G. Fubini
(w/o attachment)

IMPLEMENTATION PLAN

SUBJECT AREA: FUNDING FOR RESEARCH, EQUIPMENT, AND FACILITIES

Recommendations

1. The USDRE give guidance and support to the Services to increase 6.1 Research funding to universities, over and above any special provisions for instrumentation, to accommodate real sustained growth.

   Responsible Office: DUSD(R&AT)

2. Within the overall increase in funding for all university research, target critical needs for special attention.

   Responsible Office: DUSD(R&AT)

3. The USDRE direct the Defense Acquisition Regulations Committee to revise current procurement policies and regulations to encourage additional Independent Research and Development (IR&D) for industry support of university research.

   Responsible Office: DUSD(R&AT)

4. The USDRE direct Services to provide funding to the universities for a sustained period, over and above 6.1 Research funding, specifically aimed at improving university equipment and facilities.

   Responsible Office: DUSD(R&AT)

5. Continue Tri-Service funding and coordination on large capital budget items for DoD programs in connection with ongoing research contracts.

   Responsible Office: DUSD(R&AT)

SUBJECT AREA: MANPOWER AND TRAINING

Recommendations

1. The USDRE authorize each of the Services to award additional science and engineering graduate fellowships and educational support annually similar to those contained in the FY 1983 budget (40-50 new research fellowships at the $15,000 level). Award fellowships to U.S. citizens only.

   Responsible Office: DUSD(R&AT)

2. Continue to support graduate student assistantships in defense-related research programs within the targeted discipline areas at levels consistent with the prevailing economic climate and university compensation policy.

   Responsible Office: DUSD(R&AT)

3. The Secretary of Defense direct the Services to increase funding of existing ROTC programs, broadening their coverage and scope, if necessary, to attract outstanding students to military careers.

   Responsible Office: ASD(MRA&L)

SUBJECT AREA: EXPORT CONTROL

<u>Recommendations</u>

1. The USDRE initiate a process whereby the research and development experts in OSD and the Military Departments, in consultation with the universities, would develop mutually acceptable terms for reviewing university research contracts.

   Responsible Office: DUSD(R&AT, IP&T)

2. For the dissemination of technical information in DoD-funded university research, draft clear, concise guidelines that are not overly restrictive and that would not inhibit the legitimate flow of scientific information.

   Responsible Office: DUSD(R&AT, IP&T)

3. After implementing guidelines for DoD-funded research, negotiate similar guidelines for other federally-funded research and, if necessary, non-federally-funded research. Care must be exercised to include only research potentially subject to the International Trade in Arms Regulations (ITAR) or the Export Administration Regulations (EAR).

   Responsible Office: DUSD(R&AT, IP&T)

4. Coordinate activities with the Departments of State and Commerce to reduce to a minimum the necessity of university researchers to apply formally to the Government for export licenses.

   Responsible Office: DUSD(R&AT, IP&T)

5. The USDRE make available an unclassified version of the Militarily Critical Technologies List (MCTL) as a means of educating the university community about DoD's technology transfer concerns.

   Responsible Office: DUSD(IP&T)

SUBJECT AREA: OTHER CONCERNS

Recommendations

1. The USDRE create a forum to allow periodic consultations between senior university representatives and DoD officials on the full range of research-related needs and issues that affect the Department's ties with universities. The Defense Science Board, which already has university representation in its membership, could serve as the mechanism for creating such a forum.

   Responsible Office: DUSD(R&AT)

2. Continue to simplify acquisition procedures and regulations for procuring basic research from universities. Specifically:

   - Support the Short Form Research Contract (SFRC) now being tested by DoD.

   - Develop standard contractor proposal formats.

   - Eliminate "representations, certifications, and acknowledgements" that are inappropriate for universities.

   Responsible Office: DUSD(R&AT)

3. The Secretary of Defense encourage other agencies to strengthen existing foreign language and area study programs, particularly those authorized under Title VI of the Higher Education Act of 1980. In addition, the Department should assess the consequences for our national security of the weakened university research and training capabilities in these areas, and expand the use of appropriate DoD mechanisms to support work of particular significance to defense needs.

   Responsible Office: DUSD(R&AT)

4. Continue cooperating with other federal agencies and departments on research funding, fellowship awards, and other support so that the basic science and engineering disciplines with critical needs can be maintained and grow in a stable programmatic environment.

   Responsible Office: DUSD(R&AT)

5. Continue to promote closer ties and long-term relationships between faculty members in key areas and defense-related projects in DoD laboratories or Federal Contract Research Centers (FCRCs) through consulting agreements or research funding.

   Responsible Office: [illegible]USD(R&A[illegible]

6. Emphasize the importance of and opportunities available under the Intergovernmental Personnel Act, which permits university/government personnel exchanges for periods of up to two years.

   Responsible Office: DUSD(R&AT)

7. Continue the present programs of disseminating information about DOD research interests, programs, and facilities to universities and colleges.

   Responsible Office: DUSD(R&AT)

8. Through a joint effort in government and the private sector (e.g., the National Research Council), encourage the publication of a general catalogue listing fellowships, assistantships, scholarships, and manpower training grants offered by government, industry, foundations, and other institutions connected with the universities.

   Responsible Office: DUSD(R&AT)

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

In response to a request by the Committee on Armed Services of the U.S. House of Representatives to investigate the responsiveness of the U.S. universities to national security requirements, the Under Secretary of Defense for Research and Engineering constituted a Task Force of the Defense Science Board to address the following issues:

- Is there real university interest in performing classified and unclassified research with clear-cut DoD application and sponsorship?
- What problems are introduced by the high and still increasing numbers of foreign students now enrolled in science and engineering graduate schools?
- Is there adequate interaction between the universities and industry in research and development programs?
- Does the implementation of current export controls on information relating to munitions list technologies restrict research and teaching activities conducted by universities?
- Are the current DoD contracting and grant policies and procedures appropriate for universities?
- What should be the role of the DoD in supporting basic research vis-a-vis that of the National Science Foundation and other agencies? How and to what extent should DoD support research that will promote science and engineering education?
- Is the output of trained manpower for undergraduate and graduate schools adequate to meet critical national defense needs in the decade ahead?

The findings of the Task Force are in agreement with testimony received by the Research and Development Subcommittee of the House Armed Services Committee in April 1981, as well as remarkably similar testimony on the condition of the industrial base received the preceding year. Both the industrial and academic communities have been unable to keep pace in their abilities to support the nation's defense needs. The Task Force's findings and recommendations concerning the universities' responsiveness to national security requirements are as follows.

FINDINGS

In general, the Task Force found that there is a serious national problem in the ability of our academic institutions to perform defense research and to educate adequate numbers of scientists and engineers in certain disciplines where shortages are anticipated. The universities, however, have expressed a real interest in and are capable of upgrading their capabilities to the point where they are properly responsive to national defense needs. Specific attention was given to the following areas.

FUNDING FOR RESEARCH, EQUIPMENT, AND FACILITIES

The Task Force was primarily concerned with the maintenance of a strong research capability in the midst of budgetary uncertainties and changing national priorities. The Task Force observed that:

- Although basic research funding, as a percentage of technology base funding, has remained relatively constant, DoD funding of research has declined over the long term and will require multi-year increments of real growth to return it to its former level of support.
- DOD must be concerned about the impact on the technology base in the universities caused by budget cuts and organizational changes in non-defense agencies and departments.
- Industrial support of R&D in universities and colleges has traditionally been low level, but the university/industry relationship is healthy.
- Critical shortages in university equipment and facilities have developed in recent years.

MANPOWER AND TRAINING

The manpower problem is serious, but not as severe as anticipated. Defense needs can be met if market forces work and the large numbers of students enrolling in the nation's engineering programs are properly trained and employed. Specific findings were:

- Skilled scientists and engineers in certain fields are not being educated and trained in adequate numbers to meet the combined needs of government and industry.
- For a variety of reasons, our universities are training fewer PhDs, and fewer Americans are entering graduate school.

- Engineering schools now have a sufficient number of entrants but are hampered by the shortage of faculty.
- On the positive side, DoD is actively involved in stimulating science and engineering careers oriented toward defense-related research.

EXPORT CONTROL

If not handled properly, control of certain technical information generated by research could be a major obstacle to restoring a healthy university-DoD relationship. The question revolves around academic freedom and the need to restrict access to militarily sensitive information that might be generated in the course of university research. It was found that:

- Certain specific areas of university research, especially those conducted under DoD contract, are sensitive from an export control point-of-view. With the help of the universities, DoD must formulate clear and concise guidelines for the dissemination of technical information.
- The presence of foreign nationals in university science and engineering programs poses special problems with respect to defense-related research.

OTHER CONCERNS

Among areas of related concerns, the Task Force observed that:

- DoD has innovated many procurement practices to accommodate university research.
- There is renewed recognition by DoD that there are shortages of qualified personnel in areas such as languages that will impact intelligence and foreign policy activities of the U.S. Government, including defense.
- The U.S. is not always able to capitalize on the knowledge and skills acquired by foreign citizens who are trained in U.S. graduate schools.

RECOMMENDATIONS

To ensure the continuing strength and vitality of the research and training capabilities of universities, the Task Force recommends the following actions be taken by the Department of Defense.

FUNDING FOR RESEARCH, EQUIPMENT, AND FACILITIES

- The USDRE give guidance and support to the Services to increase 6.1 Research funding to universities, over and above any special provisions for instrumentation, to accommodate real sustained growth.

- Within the overall increase in funding for all university research, target critical needs for special attention.

- The USDRE direct the Defense Acquisition Regulations Committee to revise current procurement policies and regulations to encourage additional Independent Research and Development (IR&D) for industry support of university research.

- The USDRE direct Services to provide funding to the universities for a sustained period, over and above 6.1 Research funding, specifically aimed at improving university equipment and facilities.

- Continue Tri-Service funding and coordination on large capital budget items for DoD programs in connection with ongoing research contracts.

MANPOWER AND TRAINING

- The USDRE authorize each of the Services to award additional science and engineering graduate fellowships and educational support annually similar to those contained in the FY 1983 budget (40-50 new research fellowships at the $15,000 level). Award fellowships to U.S. citizens only.

- Continue to support graduate student assistantships in defense-related research programs within the targeted discipline areas at levels consistent with the prevailing economic climate and university compensation policy.

- The Secretary of Defense direct the Services to increase funding of existing ROTC programs, broadening their coverage and scope, if necessary, to attract outstanding students to military careers.

EXPORT CONTROL

- The USDRE initiate a process whereby the research and development experts in OSD and the Military Departments, in consultation with the universities, would develop mutually acceptable terms for reviewing university research contracts.

- For the dissemination of technical information in DoD-funded university research, draft clear, concise guidelines that are not overly restrictive and that would not inhibit the legitimate flow of scientific information.

- After implementing guidelines for DoD-funded research, negotiate similar guidelines for other federally-funded research and, if necessary, non-federally-funded research. Care must be exercised to include only research potentially subject to the International Trade in Arms Regulations (ITAR) or the Export Administration Regulations (EAR).

- Coordinate activities with the Departments of State and Commerce to reduce to a minimum the necessity of university researchers to apply formally to the Government for export licenses.

- The USDRE make available an unclassified version of the Militarily Critical Technologies List (MCTL) as a means of educating the university community about DoD's technology transfer concerns.

OTHER CONCERNS

A DOD Forum for University Concerns

- The USDRE create a forum to allow periodic consultations between senior university representatives and DoD officials on the full range of research-related needs and issues that affect the Department's ties with universities. The Defense Science Board, which already has university representation in its membership, could serve as the mechanism for creating such a forum.

Contracting Procedures

- Continue to simplify acquisition procedures and regulations for procuring basic research from universities. Specifically:

  - Support the Short Form Research Contract (SFRC) now being tested by DoD.

  - De elop standard contractor proposal formats.

  - Eliminate "representations, certifications, and acknowledgements" that are inappropriate for universities.

Foreign Languages and Area Studies

- The Secretary of Defense encourage other agencies to strengthen existing foreign language and area study programs, particularly those authorized under Title VI of the Higher Education Act of 1980. In addition, the Department should assess the consequences for our national security of the weakened university research and training capabilities in these areas, and expand the use of appropriate DoD mechanisms to support work of particular significance to defense needs.

Interagency Coordination

- Continue cooperating with other federal agencies and departments on research funding, fellowship awards, and other educational support so that the basic science and engineering disciplines with critical needs can be maintained and grow in a stable programmatic environment.

Faculty Involvement

- Continue to promote closer ties and long-term relationships between faculty members in key areas and defense-related projects in DoD laboratories or Federal Contract Research Centers (FCRCs) through consulting agreements or research funding.

- Emphasize the importance of and opportunities available under the Intergovernmental Personnel Act, which permits university/government personnel exchanges for periods of up to two years.

Information

- Continue the present programs of disseminating information about DOD research interests, programs, and facilities to universities and colleges.

- Through a joint effort in government and the private sector (e.g., the National Research Council), encourage the publication of a general catalogue listing fellowships, assistantships, scholarships, and manpower training grants offered by government, industry, foundations, and other institutions connected with the universities.

CHAPTER 1

INTRODUCTION

1.0 <u>INTRODUCTION</u>

1.1 THE UNIVERSITIES AND NATIONAL DEFENSE

On April 3, 1981, the Research and Development Subcommittee of the Committee on Armed Services, U.S. House of Representatives, heard testimony on the capability of the academic community to respond to U.S. defense needs in areas of research, development, and training of scientists and engineers. The substance of these hearings was remarkably similar to that of more extensive hearings held the previous year on the condition of the industrial base. It appears that the industrial and academic communities have been unable to keep pace in their abilities to support the nation's increasingly complex and sophisticated defense needs.

In opening remarks at the hearings, Honorable Melvin Price, Chairman of the Subcommittee on Research and Development, underscored the gravity and breadth of the problem:

- The Soviet Union is producing many more scientists and engineers than are graduating from U.S. institutions.
- In the U.S., industrial opportunities are attracting engineers at the bachelor degree level, many of whom might have gone to graduate school and earned their doctorates.
- Foreign nationals constitute a large percentage of the students now engaged in graduate study, particularly in engineering.
- The age of research instrumentation and equipment in graduate school laboratories is inhibiting the quality of education and research, even in top U.S. universities.
- There are selective needs in areas other than science and engineering. For example, the State Department and Central Intelligence Agency, among others, were able to hire only a fraction of the needed people with expertise in foreign languages.

Congressman Price concluded "we cannot continue to eat our own seed corn in the area of technology and hope to remain a technologically superior country in the years to come."

1.2 DEFENSE SCIENCE BOARD STUDIES

The report of the 1976 DSB Summer Study on <u>Fundamental Research in Universities</u> noted that a major source of innovation for future defense needs resides in the university community and urged that DoD reestablish and stimulate its relationship with that community. The conclusions of that study remain generally valid today. The Defense Science Board has also treated these issues in more recent efforts:

- The 1980 DSB Summer Study on Industrial Responsiveness* was undertaken in response to questions raised by the House Armed Services Committee in their 1980 hearings on military posture.

- The 1981 DSB Summer Study on the Technology Base** considered the contributions of universities (among others) to the overall health of the U.S. technology base.

- This Task Force on University Responsiveness To National Security Requirements was formed to complete the work begun in the Technology Base Study and to provide a response to the House Armed Services Committee.

1.3 STUDY TASKS

On October 13, 1981, Dr. Richard DeLauer, Under Secretary of Defense for Research and Engineering, formally requested that this Task Force be formed to provide the coordinated response to a specific House Armed Services Committee request following the April 1981 hearings. The Committee requested that DoD conduct a study, similar to the DSB 1980 Summer Study on Industrial Responsiveness, to address university responsiveness to national security requirements. The Terms of Reference establishing and charging the Task Force are presented in Appendix A. The Task Force was asked to address the following questions:

1) Is there real university interest in performing classified and unclassified research with clear-cut DoD application and sponsorship? If so, are the conditions under which this research would be performed compatible with national security interests? If not, what steps can be taken (by either DoD or the universities) to improve the situation?

2) What problems are introduced by the high and still increasing numbers of foreign students now enrolled in science and engineering graduate schools? What, if anything, can DoD do about this impact on: (a) our future DoD supply of high quality technical personnel; and (b) the present conduct of university research on DoD subjects under reasonable security conditions?

---

* Report of the Defense Science Board 1980 Summer Study Panel on Industrial Responsiveness, Office of the Under Secretary of Defense for Research and Engineering, January 1981.

** Report of the Defense Science Board 1981 Summer Study Panel on Technology Base, Office of the Under Secretary of Defense for Research and Engineering (Secret), November 1981.

3) Is there adequate interaction between the universities and industries in research and development programs of DoD interest? If not, what incentive should DoD provide to increase this interaction?

4) Does the implementation of current export controls on information relating to munitions list technologies restrict research and teaching activities conducted by universities? If it does, what action should be taken to implement mutually satisfactory measures to accommodate both DoD and university needs?

5) Are the current DoD contracting and grant policies and procedures appropriate for universities? If not, what actions should be taken to change DoD rules?

6) What should be the role of the DoD in supporting basic research vis-a-vis that of the National Science Foundation and other agencies? How and to what extent should DoD support research that will promote science and engineering education?

7) Is the output of trained manpower for undergraduate and graduate schools adequate to meet critical national defense needs in the decade ahead? If not, what steps might be taken to improve the situation?

The Task Force panel members and staff are listed in Table 1-1. Individuals who made presentations at Task Force meetings are named in Appendix B; names of other attendees are also included.

1.4 ORGANIZATION OF THE REPORT

- Chapter 2 reviews the current status of academic research and the shortfalls in science and engineering manpower that are affecting defense capabilities.
- Chapter 3 focuses on DoD's needs and its current relationship with the universities.
- Chapter 4 deals with the specific issue of export control and the transfer of technical information that could benefit a potential adversary.
- Chapters 5 and 6 contain the Findings and Recommendations.

TABLE 1-1

DEFENSE SCIENCE BOARD TASK FORCE ON UNIVERSITY RESPONSIVENESS

Chairman	
Dr. Ivan L. Bennett, Jr.	Executive VP Health Affairs, NYU, Provost and Dean, NY Med. Cen.
Executive Secretary	
Dr. Samuel A. Musa	Staff Specialist for Electronic Warfare & Target Acquisition Office of Under Secretary of Defense for Research & Engineering
Members	
Dr. John L. Allen	Private Consultant
Dr. John M. Deutch	Department of Chemistry Massachusetts Institute of Technology
Dr. Norman Hackerman	President Rice University
Dr. Richard L. Haley	Assistant Deputy Science and Technology USA Material, Development, and Readiness Command
RADM Leland Kollmorgen, USN	Chief of Naval Research
Dr. Gerald F. Tape	Special Assistant to the President Associated Universities, Inc.
Brig. Gen. Brien D. Ward, USAF	Director of Laboratories Air Force Systems Command
Major Assistance	
Dr. John C. Crowley	Director, Federal Relations for Science Research Association of American Universities
Mr. Bradford L. Smith, Dr. Patrick P. McDermott, Dr. Richard H. Abrams, Jr.	B-K Dynamics, Inc.

CHAPTER 2

RESEARCH, DEVELOPMENT, AND THE NATION'S UNIVERSITIES

2.0 RESEARCH, DEVELOPMENT, AND THE NATION'S UNIVERSITIES

2.1 INTRODUCTION

The research capabilities of the nation's universities have not kept pace with the increasingly sophisticated technical needs of our military defense systems. Today, there is serious doubt about the universities' capacity to respond to national security needs, as reinforced by presentations made to this Task Force and by testimony of distinguished university administrators and researchers at the April 1981 Congressional hearings.

Fortunately, the universities' attitudes today are different from those of the Vietnam era. The tensions of the DoD-university relationship that characterized that era have diminished, and the universities are receptive to positive actions to restore the strength and effectiveness of that relationship and to augment their research capabilities. To better understand the scope and size of the required actions, some of the key problem areas are examined in this section.

2.2 TRENDS IN R&D FUNDING

The best indicators of the slowing of national interest in science are the national trends that developed over the years from 1968 to 1980:

- R&D funds as a fraction of the federal budget -- down 36%.
- R&D funds as a fraction of the GNP -- down 19%.
- Scientists and engineers engaged in R&D as a fraction of the labor force -- down 9%.

During the same period, the U.S.S.R., Germany, and Japan were increasing their R&D investments (as a percentage of GNP); at the same time, they were increasing the science and engineering component of the labor force. These data are summarized in Table 2-1, along with data on R&D dollar expenditures. Although the trends of U.S. proportional R&D investments are down, it is clear that the U.S. remains by far the most supportive country of R&D in absolute investment.

The national investment in R&D from 1968 is shown in Figure 2-1. In constant 1972 dollars, national R&D expenditures have increased approximately 36% in the period 1972-82, an annual real growth rate of approximately 3% -- a growth rate considerably below that of most of our allies and of the U.S.S.R. A U.S. commitment to strong growth in R&D by either federal or non-federal sources is not evident from the trends shown in the figure.

Focusing only on basic research, as opposed to total R&D, the indicators show that between 1968 and 1980:

- Basic research as a fraction of the total federal budget -- down 27%.
- Basic research as a fraction of the GNP -- down 16%.

TABLE 2-1

COMPARATIVE R&D FUNDING AND MANPOWER DATA

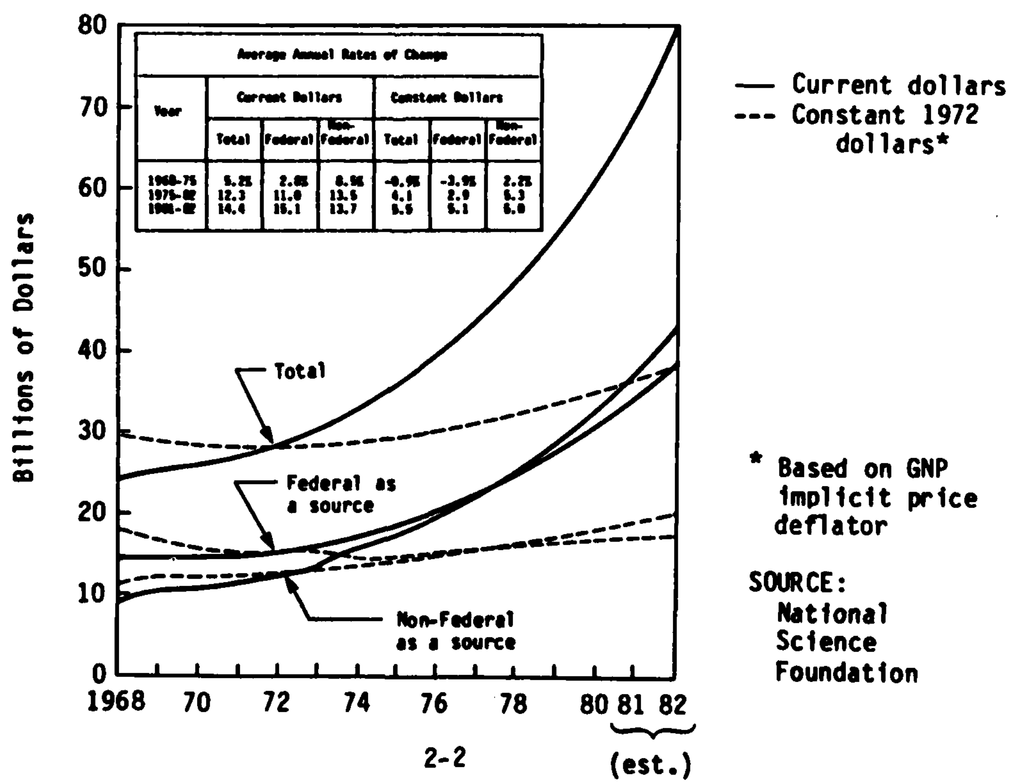
	Percent Change in R&D Funding as Fraction of GNP (1968-80)	Annual R&D Investment (Dec. 31, 1979) ($ Billion)	Percent Change in Scientists/ Engineers as Fraction of Labor Force (1968-80)	Scientists and Engineers in R&D per 10,000 Work Force (1978-79)
U.S.	-19%	54.215	-9%	59.9
U.S.S.R	+14%	30.162	+62%	84 to 95*
Japan	+19%	20.063	+70%	49*
West Germany	+16%	17.366	+75%	44.3

* Definitions of Scientist, Engineer, Full Time Equivalent differ from U.S. and West Germany definitions.

Source: NSF Division of Science Resources Studies.

FIGURE 2-1

NATIONAL R&D EXPENDITURES



2.3 SUPPLY AND DEMAND OF SCIENTISTS AND ENGINEERS

Graduate and undergraduate scientists and engineers are currently in great demand, some specialties and subspecialties being in critically short supply. Defense needs for skilled manpower must compete with non-defense needs for the same skills. In some fields of specialization the intense competition is pushing salaries to levels that are luring teaching and research faculty away from university employment to the private sector. At the same time, the salary levels are inducing large numbers of undergraduates to enroll in science and engineering programs. These twin factors of constant or slightly decreasing numbers of faculty and burgeoning teaching loads are straining the capability of the institutional machinery to educate the nation's scientists and engineers.

Demand (current and projected) is most intense in specific disciplines. A joint study (NSF and Department of Education) completed in October 1980 shows the most pronounced shortage to be in computer science specialists. There is, however, a great deal of cross-occupational mobility. As highly proficient scientists and engineers realize the professional possibilities of computers (as well as the intellectual challenges), more movement from other fields to computer specialization is expected.

In engineering, there are current shortages of chemical, electrical, petroleum, industrial (particularly processing), and oceanographic engineers. Supply and demand is balanced for mechanical, aeronautical, civil, and nuclear engineers. A more specific sub-disciplinary study is not available but, overall, the number of shortages has lessened from a few years ago.

The physical and natural sciences have shortages of certain kinds of microbiology/bioengineering professionals that can be traced to the recent interest in genetic engineering. Also evident is an imbalance in the number of available statisticians. The supply of physicists, chemists, meteorologists, and other physical scientists is in balance with the number of vacancies. There appears to be a surplus of basic biologists and social scientists.

A DoD White Paper on the Status of Scientific and Engineering Personnel in the U.S. (prepared for the Under Secretary for Research and Engineering in September 1981) surveyed a number of manpower studies and highlighted deficiencies in certain technical areas.

- Current demand for certain types of engineers represents between 15% and 20% more than the number of accredited graduates. For example, there are four jobs for every nuclear engineering graduate and ten jobs for every computer science graduate with an advanced degree.

- The American Electronics Association (AEA) identified "hot spots" of growth in certain fields over the next five years:

  Computer Software Engineers
  Electronic Engineer Technologists
  Analyst/Programmers
  Other Computer Professionals
  Applications Programmers
  Jr. Technicians/Testers
  Field Service Technicians
  Micro-Electronic Technicians
  Laser Technicians
  Drafters
  Design Drafters

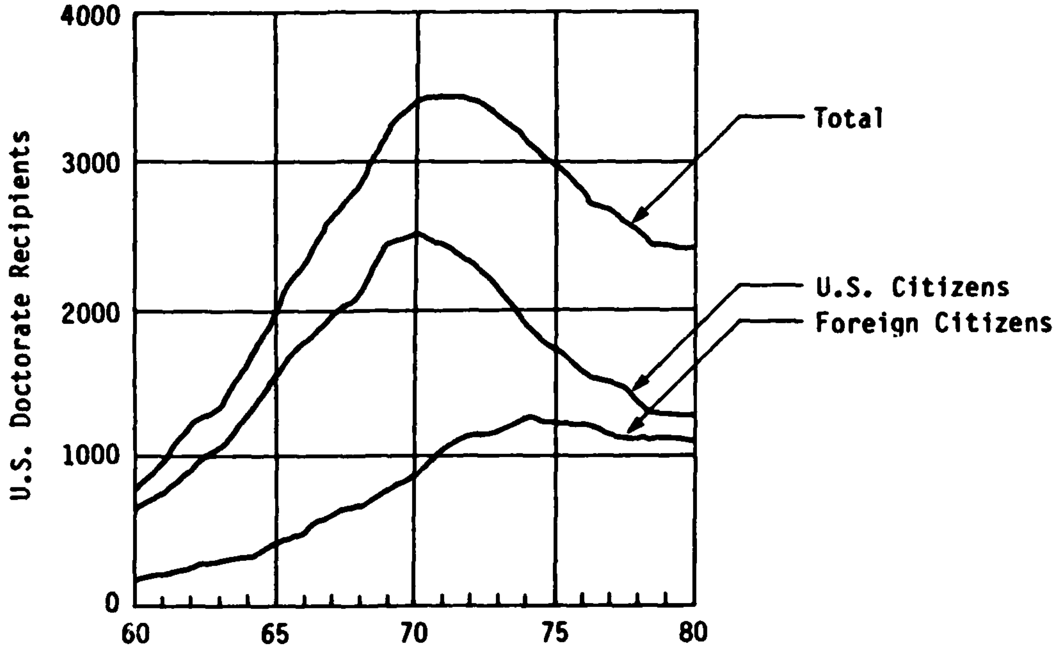
- The aerospace industry anticipates difficulties since the production of aeronautical engineers is down 41% since 1970. Additional shortages of technical support personnel are expected to aggravate the problem.

- The August 1981 issue of Defense Electronics reports that a new survey of 500 companies revealed serious engineering manpower shortages in computer software, avionics, and electrical systems disciplines.

The aggregate statistics for current shortages in scientific or engineering disciplines do *not* show the dramatic shortages of advanced degree holders. However, some indication of this problem may be obtained from Figure 2-2, which shows the number of engineering PhD recipients from 1960 to 1980. (Comments about the U.S. and foreign citizen components of the total may be found in the next section.)

FIGURE 2-2

NUMBER OF U.S. ENGINEERING DOCTORATE RECIPIENTS



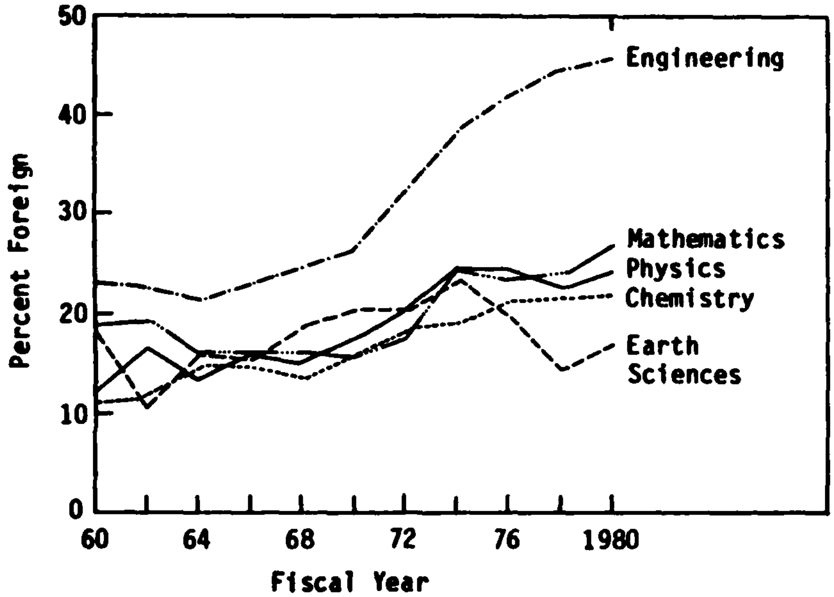
From the 1972 peak of 3,774, the annual number of PhDs granted declined 27% to the 1980 level of 2,751. As the data show, virtually all of the drop is attributable to a decline in awards to U.S. citizens. The reasons suggested for this are many, two of the major ones being: (1) a large and growing differential between private sector salaries for graduating baccalaureates and stipends for graduate assistantships/fellowships, and (2) growing opportunities for satisfying career development in industrial employment. Clearly, obtaining an advanced degree is an attractive option for fewer and fewer U.S. citizens.

2.4 FOREIGN STUDENT ENROLLMENTS

In addition to the decline in the *number* of PhDs produced by the nation's universities, there has been an increase in the percentage of foreign nationals receiving the doctorate, particularly in engineering. The data for Figure 2-2 showing that, by 1979-80, 46.3% of all engineering doctorates were awarded to foreign citizens, also show that the rapid increase in percentage of foreign students was not caused by a rapid increase in numbers, but rather, by a drop in the number of U.S. citizens earning the degree. (However, unpublished NSF data show that the actual number of foreign doctorate recipients has declined since the mid-1970s.) The situation with respect to percentages of foreign doctorates in other disciplines is shown in Figure 2-3.

FIGURE 2-3

PROPORTION OF NON-U.S. DOCTORATE RECIPIENTS BY FIELD, 1960 TO 1980



Source: Summary Report 1980: Doctorate Recipients from United States Universities. Commission on Human Resources: National Research Council. National Academy Press, Washington, DC, 1981 pg. 81

Preliminary data from a study (to be published by NSF) show that foreign participation in higher education in the U.S. became increasingly pronounced in the seventies, especially at the graduate school level. Two major factors underlie this trend:

- Increased demand for U.S. training of foreign scientists and engineers.
- Relative to industry salaries, low stipends for graduate assistantships and fellowships were more acceptable to foreign graduate students, many of whom received additional support from their governments.

The effects of these trends are seen in three areas:

Graduate Training

- Enrollment of foreign students doubled during the 1970s for both undergraduate and graduate levels. Proportionally the levels:

  -- remained about 2% of undergraduate population

  -- oscillated between 7% and 9% (peaking at 12%, 1979) for the graduate population.

- The proportion of foreign full-time graduate students in science and engineering rose from 16% in 1974 to 20% in 1979.

- The foreign share of graduate enrollment in science and engineering is more than double the graduate enrollment in all other fields.

- Although foreign graduate student enrollment rose in all science and engineering fields, the most pronounced growth took place in engineering and mathematical/computer science.

  -- Over 40% (16,200) of 1979 graduate enrollment in engineering consisted of foreign students.

  -- Over 30% (4,300) of enrollment in mathematical/computer sciences consisted of foreign students.

Doctorate Awards

- One out of every five science and engineering doctorates (about 3,600) was awarded to foreign citizens in 1979.

- Almost one-half (1,200) of the engineering doctorates granted in 1979 went to foreign citizens, but as previously noted, this is a function of the decrease in the number of U.S. citizens receiving engineering PhDs.

- The share of all science and engineering doctorates awarded to foreign citizens increased steadily from about 15% in 1960 to 23% in 1974. It has remained relatively stable to date.

- About 30% of the foreign citizens awarded science and engineering doctorates in 1979 planned to remain in the United States.

- In 1979, roughly 12% of all engineering doctorates working in the U.S. were foreign citizens.

- More than one-half of the foreign students receiving science and engineering doctorates in the 70s were from the Middle East and Asia.

Post-Doctorate Training

- Foreigners made up about one-third (6,075) of the science and engineering post-doctorates employed in doctorate granting institutions in 1979. However, this share is down from almost one-half in 1967.

- Two out of every three engineering post-doctorates were foreigners in 1979; the ratio was one to ten in 1969.

After receiving their education in the U.S., some foreign doctorate recipients would prefer to remain in this country rather than to return to their country. At present, holders of PhDs in science and engineering can obtain a one-year non-immigrant visa (H-1) based on their special skills. However, at the expiration of that visa, there are presently only two alternatives: (1) the scientist/engineer can obtain a four-year visa (E) if hired by a firm or organization of a U.S. trading partner/nation to work for them in this country; or (2) the scientist/engineer can apply for permanent immigrant status, but no preference is given to the application for special skills or training, whether or not obtained while in the U.S. Depending on the applicant's country of origin, such a scientist/engineer may be forced to leave the country involuntarily.

Little statistical information is available to document the loss to the U.S. of scientists/engineers educated at U.S. universities and trained with U.S. funds. However, using unpublished NSF data, estimates can be calculated to show that about 70% of foreign science and engineering doctorate recipients leave the U.S. Although the actual number or percentage of involuntary departures is not known, anecdotal information abounds to support the belief that the numbers are large and their departures are harmful to the U.S.

Many in the field of higher education believe that the education of foreign nationals is an important component of an open society, and that the large foreign student component in the nation's universities is a tribute to the quality of U.S. education. The Task Force supports this belief, but is concerned about the problem clearly posed by foreign students and their involvement in the generation and transfer of military sensitive information. (This topic is thoroughly discussed in Section 4, Export Control and the Universities.) Additionally, the Task Force believes that the striking shift in the proportion of foreign students in certain fields could be corrected if financial incentives for U.S. students were improved.

2.5 FACULTY SALARIES

The development and retention of a high quality teaching and research faculty is difficult at any time, but is currently more of a definite problem because of the large inequities between university and industrial salaries. Faculty salaries are no longer competitive in the marketplace. (For a fair comparison between industry and universities, total financial compensation, including summer employment and consulting arrangements, should be examined. However, data to permit this comparison are not readily available. It should also be noted that consulting arrangements and lucrative summer employment opportunities are not uniformly distributed among all faculties.)

- "While new PhDs in academic positions are typically offered annual salaries in the $15,000 to $20,000 range, the corresponding salaries in high-technology industry are in the $30,000 to $40,000 range. With this factor of 2, universities can no longer afford to hire their most able graduates -- the teaching faculty of tomorrow...we are indeed eating the seed corn."*

- At present, salaries of assistant professors in certain fields of engineering range between $25,000 and $30,000 a year, and additional financial support is required for the initiation of research.

- The median salary for university chemists ten to fourteen years after receiving their B.S. degrees is $20,000; the equivalent salary in industry is $33,500.**

- The DoD White Paper on the Status of Scientific and Engineering Personnel in the U.S. prepared for the Under Secretary of Defense for Research and Engineering (September, 1981) reported that nationwide, there are currently more than 2,000 unfilled engineering and 200 computer science faculty positions. Academic salaries are 25-30% lower than industry's, and educational institutions cannot attract teachers from the small supply of available PhD graduates.

The salary differential also acts to reduce the enrollment of graduate students, many of whom might be expected to enter university faculty positions upon receiving their doctorate. Industry salaries and career development opportunities attract the top baccalaureates away from graduate education, thus depleting the faculty feedstock. The swelling enrollment of undergraduate engineering students is further straining the resources of an already embattled faculty.

2.6 FACILITIES AND EQUIPMENT

Slowed acquisition of equipment, inadequate renovation of facilities, and austere maintenance budgets, largely resulting from tightening federal programs during the past decade, have created inefficiencies and inadequacies in the university laboratories of this country. These are detailed below.

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* D. Allan Bromley, <u>Science</u>, p 4505, Vol 213 (1981).

** <u>Salaries, 1981</u>, American Chemical Society, Washington, DC, July, 1981.

It is important to note that similar deficiencies in both instrumentation and facilities have developed in the national laboratories operated by federal agencies, especially DoD laboratories, during this period of time. Industry appears to have kept pace with needs in this area, but a reaffirmation of the federal commitment to research must finally address, not only the universities, but also the in-house laboratories.

Scientific Instrumentation

In June 1980 the Association of American Universities completed a report for the National Science Foundation on the scientific instrumentation needs of universities. In assessing the instrumentation needs of university researchers, the report concluded, "It is a telling fact that the equipment being used in the top-ranked universities has a median age twice that of the instrumentation available to leading industrial research laboratories."* This striking disparity is graphically displayed in Figure 2-4, taken from the AAU instrumentation study.

The report concluded that "the quality of research instrumentation in major university laboratories has seriously eroded. Not all, but many researchers in the nation's best-funded universities are struggling to work effectively with obsolete tools." This finding concerning university inventories is negated neither by the ability of some top researchers to "find" the equipment they need nor by university efforts to use their equipment more efficiently.

Federal funding for equipment acquisition has been declining in a period when instrumentation requirements in many fields have increased dramatically. An additional problem is that of inadequate operating and maintenance funds. Operating and maintenance costs cover a variety of expenses -- service contracts, replacement parts, support of shop personnel and equipment, air-conditioning for computers, and equipment operators. When these costs cannot be met, research instrumentation is not properly maintained, faculty and students are forced to function as technicians, and, in general, the effectiveness of research and training is degraded.

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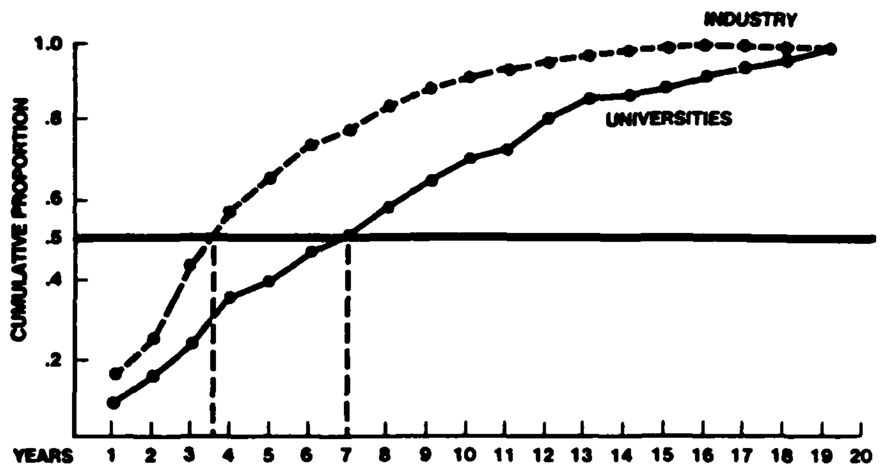
* "The Scientific Instrumentation Needs of Research Universities," a report to the National Science Foundation by the Association of American Universities, June, 1980.

FIGURE 2-4

AGE OF INSTRUMENTATION IN INDUSTRY AND UNIVERSITIES

(Proportion of instrumentation inventory purchased less than n years ago)

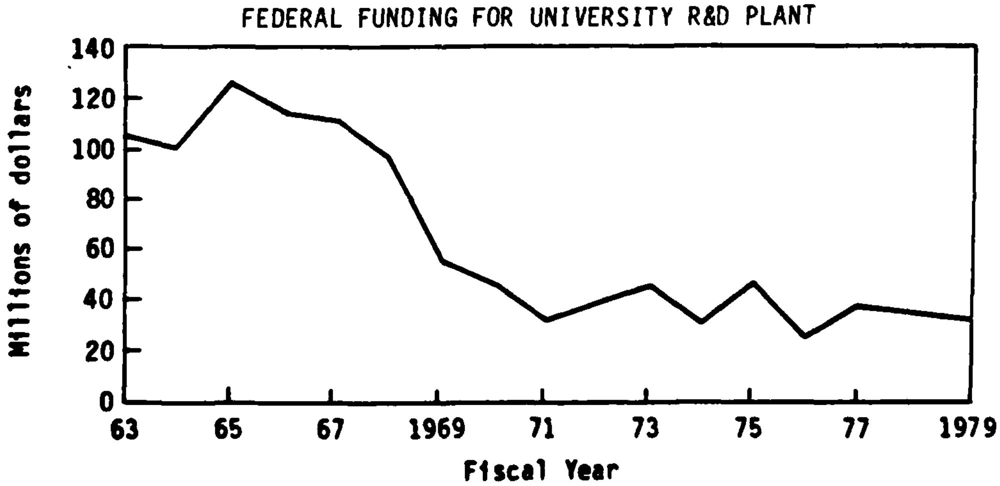


Facilities

The research facilities in many of the nation's leading research universities are in a state of advancing deterioration. For more than a decade, the Federal Government has not supported programs to upgrade and rehabilitate the university departmental research laboratories in which most federally-supported basic research and advanced training programs are carried out. In addition, funding for individual research projects usually provides no support for the rehabilitation of laboratory space and often insufficient support for the acquisition of the instruments needed to carry out frontier research. The decline in federal funding for R&D plant at universities and colleges is shown in Figure 2-5.

FIGURE 2-5

FEDERAL FUNDING FOR UNIVERSITY R&D PLANT



Source: National Science Foundation

The financial needs of universities for new construction and major research equipment are enormous. Fifteen universities surveyed by the Association of American Universities estimated that they must spend nearly $765 million (current dollars) over the next three years for research facilities and special equipment for current faculty only. *

* "The Nation's Deteriorating University Research Facilities: A Survey of Recent Expenditures and Projected Needs in Fifteen Universities," Committee on Science and Research of the Association of American Universities, July 1981.

CHAPTER 3

THE UNIVERSITY-DOD RELATIONSHIP

3.0 THE UNIVERSITY-DOD RELATIONSHIP

3.1 INTRODUCTION

3.1.1 Department of Defense Needs

Research

Basic research, wherever performed, whether or not defense-related, is neither a frill nor a luxury. The vitality of important sectors of our economy -- aerospace and computers to mention only two -- flows from basic scientific and engineering work done earlier with little or no preconception of many of its eventual applications. Similarly, the capabilities of current-day weapon systems depend upon earlier advances in basic research; the obvious corollary of this proposition is that the basic research conducted today will form and drive the characteristics and capabilities of our future military systems.

The Department of Defense and the military Services have long recognized the contributions of university research to the success of their missions, and have long supported basic and applied research along with other sponsors: industry, the universities and colleges themselves, other non-profit organizations, and other federal agencies. The role of the Department as a sponsor and user of university research is well-established because ongoing research programs are vitally important to continuing technological supremacy.

Numerous panels of distinguished scientists and policy makers have grappled with formulating the connection between DoD's basic research programs (wherever performed) and overall national defense objectives. In June 1978, the Galt Panel of the President's Office of Science and Technology Policy stated three fundamental reasons why research is important to DoD:

- Only research can fill gaps in knowledge that are the causes of many technological problems.
- Research is a source of new concepts that lead to major changes in operational capability.
- Research is a source of insight for policy-makers who must evaluate and react to technological developments.

Manpower Training

Another area of pressing need being experienced by the Department of Defense is the requirement for skilled civilian and military personnel to research, develop, and operate technically sophisticated weapon systems. Personnel trained in science and engineering are required in the operating Services, in DoD and contractor laboratories, in industry, and in the Department's program offices. To indicate the size of the skilled manpower base, DoD laboratories alone in FY 1979 were authorized for 93,820 total positions, of which 18,288 (or 19%) held bachelor degrees, 9,259 (or 10%) held master's, and 4,368 (or 5%) held the doctorate. Keeping in mind that in FY 1982 only 24% of DoD's R&D budget of $21,321 million was expended in government laboratories, the Department's need for skilled scientists and engineers for R&D alone extends far beyond the manpower needs of in-house laboratories.

To account for and project the skilled manpower needs for defense and non-defense sectors of the economy, the Department of Defense has implemented a large computer model to quantify the requirements for various skills and disciplines. The results of a recent compilation of model runs are summarized in Table 3-1 for occupations of interest to the Task Force. For these disciplines, the 1981 manpower needs for defense-related work in all sectors of the economy total about 229,000. Keeping in mind that projections are subject to the vagaries of time and fortune (as well as the assumptions of the model), the defense-related manpower needs for 1987 are projected to increase 38% to about 316,000. This increase is to occur in an economy that will demand over 2,289,000 skilled workers in the disciplines shown, an increase of over 343,180 skilled personnel in six years.

Advice and Consultation

A final area of DoD need that must be mentioned is that for advice and consultation. Traditionally, the Department of Defense has relied on advisory panels and boards of distinguished scientists and engineers to provide information and assesments for the formulation of defense policy, to provide guidance in policy analysis and evaluation, and to provide expertise in clearly demarcated technical areas. The Department has also utilized experts from industry and universities throughout the weapon acquisition process to supplement and reinforce technical expertise available in government laboratories. As the technical demands increase on a shrinking population of government employees, the need for outside expertise will continue and will grow.

The teaching and research faculties of the universities and colleges, in addition to their primary role in educating the nation's scientists and engineers, are an essential source of advisors and consultants to DoD. Since DoD is the sole customer for all of its products and services, advice on various matters from objective "outsiders" is particularly useful. Scientists and engineers from both industry and the universities can and do function in advisory capacities by virtue of their technical knowledge and competence. The Department of Defense is assured of a balance in the advice it receives by the presence of both industrial and university perspectives over the broad range of problems it must confront.

3.1.2 The University Role in National Defense: A Historical Perspective

The universities and colleges have played a key role in meeting Department of Defense needs in all three areas by conducting research, training scientists and engineers, and providing a pool of university researchers and experts who may be called on to provide advice and consultation on defense-related matters. The relationship between DoD and the universities cannot

TABLE 3-1

DEFENSE-INDUCED EMPLOYMENT BY OCCUPATION
(Thousands)

	1981			1987		
	Defense	Other	Total	Defense	Other	Total
Aero-Astronautic Engineers	24.03	41.07	65.10	40.62	46.54	87.16
Chemical Engineers	2.73	49.35	52.08	3.79	52.16	55.96
Civil Engineers	12.59	143.46	156.04	15.48	166.39	181.87
Electrical Engineers	45.14	261.72	306.86	61.19	298.56	359.75
Mechanical Engineers	27.21	168.62	195.83	39.17	188.14	227.31
Metallurgical Engineers	2.50	14.18	16.68	3.48	16.63	20.10
Engineers (Other)	35.85	351.68	387.53	53.28	406.42	459.70
Atmospheric & Space Scientists	0.70	11.15	11.85	1.04	11.90	12.94
Biological Scientists	1.24	60.88	62.12	1.52	68.88	70.40
Chemists	6.21	116.90	123.11	8.84	130.10	138.94
Geologists	0.85	31.19	32.04	1.30	37.18	38.48
Marine Scientists	0.48	4.60	5.08	0.60	5.14	5.75
Physicists & Astronomers	6.55	17.71	24.26	7.57	18.75	26.32
Life & Physical Scientists (Other)	1.34	6.18	7.52	1.48	5.50	6.98
Mathematicians	3.06	6.94	10.00	3.41	7.30	10.71
Statisticians & Actuaries	1.39	31.91	33.30	2.24	37.84	40.08
Computer Specialists	57.15	399.76	456.91	71.29	475.75	547.04
TOTALS	229.02	1717.30	1946.31	316.30	1973.18	2289.49

Source: Defense Economic Impact Modelling System, Office of the Secretary of Defense.

be evaluated solely by looking at the funding relationship. As will be evident, it is not the funding relationship that demonstrates the importance of the universities in defense-related matters, but other factors: the universities are unique repositories of knowledge and know-how and are the only institutions that can educate the numbers of scientists and engineers required by government and industry.

Building upon the base of university participation in defense-related research that developed during World War II, a high level of university cooperation and support for such work had been reached by the time of U.S. involvement in South East Asia. DoD funding of research peaked in 1965, and the subsequent fall-off in funding came during a time of acrimony and recrimination, accompanied by furious debate over the passage of the Mansfield Amendment. The result was a gradual weakening of university capabilities to function as performers of research and educators of scientists and engineers. (Further discussion of the funding trend is contained in the section on DoD funding of research.) Although the tensions in DoD-university relationships that were characteristic of the Vietnam era have since essentially vanished, the previously healthy relationship has not been fully restored nor has the decline in capabilities been reversed.

Today, a receptive environment exists in the universities so that, with appropriate and sufficient support,

> "research universities can promise the following: (1) that the highest quality research will continue to be conducted in university laboratories; (2) that the nation will have sufficient numbers of trained scientists, engineers, and other specialists to meet the defense-related needs of industry, government, and the universities; (3) and that research personnel will be better aware of defense problems, and those able to help with innovative ideas will be encouraged to do so."*

The positive contribution of the universities in defense-related research and development was substantiated by the appearance of 12 universities in the list of the top 500 defense contractors as published in the Federal Register of December 14, 1981 (46FR60821). These universities (University of California, Illinois Institute of Technology, Johns Hopkins University, Massachusetts Institute of Technology, New Mexico State University, Penn State University, University of Rochester, University of Southern California, University of Texas, University of Washington, Stanford University, and the University of Maryland) each received more than $10 million from DoD in FY 1981. Defense-related research is performed not only in DoD-funded university laboratories and Federal Contract Research Centers (FCRCs), but also in university-affiliated laboratories funded by other federal agencies, such as the Los Alamos Scientific and Lawrence Livermore Laboratories funded by the Department of Energy.

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* Report of the Task Force on Defense Requirements and University Preparedness to the Committee on Science and Research of the Association of American Universities, October 1981.

3.2 DOD FUNDING OF RESEARCH AND DEVELOPMENT

3.2.1 DOD's Role in the Federal Funding of University R&D

Although the Department of Defense is heavily affected by and dependent upon university capabilities and must continue to take positive actions to resolve deficiencies in these capabilities, it must be recognized that the responsibility for solving these problems is shared among several government agencies, industry, and the universities themselves. Research and development in universities is supported by many sponsors, each relying on complementary funding from the other sponsors to leverage its own expenditures. By the nature of the research investigation process and the ease of information transfer within the research community, DoD (or any other sponsor) can and does draw on the knowledge base generated by research programs funded by others; to succeed in one research program area requires success in other program areas. The universities have been effective basic research and development agents because Federal Government sponsors have shared the responsibility of maintaining a viable technology base in the universities. The extent of interdependency of federal funding for research and development is shown in Table 3-2.

TABLE 3-2

FEDERAL SUPPORT FOR CONDUCT OF R&D
AT COLLEGES AND UNIVERSITIES
($ MILLION)

	FY 1980 Actual	FY 1981 Est.	FY 1982 Reagan Budget	Percent Change FY 1980 to 1982
HHS	$2077	$2173	$2314	+11.4%
(NIH)	(1899)	(1994)	(2135)	+12.4
NSF	661	703	751	+13.6
Defense-Military	455	533	645	+41.9
Agriculture	222	241	282	+26.8
DOE	283	289	280	-1.2
NASA	171	188	196	+14.5
AID	53	60	58	+10.0
EPA	47	50	40	-14.9
Education	65	64	38	-40.6
Interior	44	37	24	-44.8
Transportation	21	19	22	+6.8
Commerce	46	44	17	-63.2
Labor	11	10	16	+38.6
Other	32	28	29	-9.4
Total, current dollars	$4188	$4439	$4712	+12.5
Constant FY 1972 dollars	(2319)	(2243)	(2226)	(-4.0)

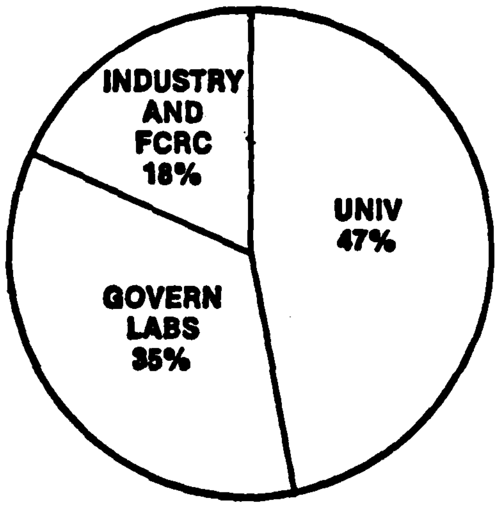
Source: "OMB Data for Special Analysis K."

3.2.2 6.1 Funding in the Universities

An examination of the funding relationship shows the universities to be more important to the research than the development effort, as would be expected. As is shown in Figure 3-1, some 47% of the Department's research budget is expended in the universities. Total funding to the universities for research from the Army, Navy, Air Force, and Defense Advanced Research Projects Agency amounts to about $327 million in FY 1982.

FIGURE 3-1

ALLOCATION OF DOD RESEARCH BUDGET BY PERFORMER



FY 82 RESEARCH BUDGET: $723 M

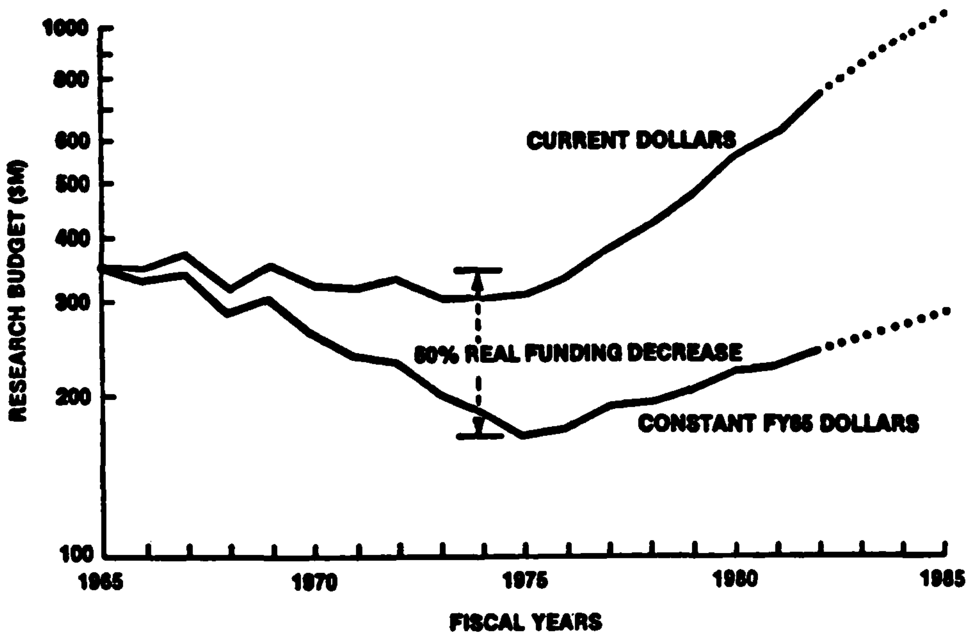
SOURCE: Office of the Under Secretary of Defense for Research and Engineering

DoD funding of the technology base (6.1 Research and 6.2 Exploratory Development) declined steadily in terms of constant dollars from 1966 to 1976. From 1976 to 1982, there has been steady growth in funding, but it has not yet reached the 1966 funding level in terms of constant dollars.

DoD funding of 6.1 Research mirrors the funding profile of the whole technology base. As shown in Figure 3-2, there was a 50% drop in funding (in constant FY65 dollars) over the period 1965 to 1975, followed by gradual growth back to only two-thirds of the 1965 level. Some have argued that the various deflators used in the calculation of constant dollar growth/decline do not reflect the higher cost of research over the general rate of inflation in the economy. If these arguments are true, research funding is in worse condition than shown in Figure 3-2.

FIGURE 3-2

RESEARCH FUNDING PATTERN



SOURCE: Office of the Under Secretary of Defense for Research and Engineering

The current upturn in funding across the board is encouraging but must be sustained to revitalize the technology base, including the universities. The research funding budgets for FY 1982 are shown in Table 3-3 for the major disciplinary areas of interest to DoD. The growth in real terms ranges from 8% to 22%, with an overall real growth rate of 8%. About 47% of the DoD research budget is directed to colleges and universities. The data of Table 3-4 show the increases in funding levels by each of the military Services and DARPA; overall, funding to the universities is up 15% in real terms from FY 1981 to FY 1982. The largest increase in real terms was from Army funding (28%), the smallest from Navy funding (6%).

TABLE 3-3

DOD RESEARCH FUNDING OF DISCIPLINARY AREAS
($ MILLION)

Scientific Discipline	FY 81	FY 82	Real Growth
Physics, Radiation Sciences, Astronomy, Astrophysics	75.6	88.3	8%
Mechanics and Energy Conversion	62.4	77.4	15%
Electronics	58.7	75.6	20%
Biological and Medical Sciences	51.8	67.8	22%
Materials	53.2	65.1	13%
Chemistry	47.8	60.1	17%
Math and Computer Sciences	44.2	53.6	12%
Oceanography	43.2	51.1	9%
Atmospheric Sciences	22.6	26.7	9%
Terrestrial Sciences	20.9	25.2	12%
Behavioral and Social Sciences	18.8	22.8	12%
Aeronautical Sciences	10.8	12.9	10%
SUBTOTAL	510.3	626.7	14%
DARPA	102.7	94.4	
USUHS	1.4	1.7	
TOTAL	614.4	722.8	OVERALL 8%

Source: Office of the Under Secretary of Defense for Research and Engineering

TABLE 3-4

ALLOCATION OF RESEARCH FUNDS TO UNIVERSITIES
($ MILLIONS)

	FY 80	FY 81	FY 82
Army	47.6	52.1	71.7
Navy	101.5	118.1	143.8
Air Force	65.1	69.5	79.0
DARPA	19.6	25.5	32.3
TOTAL	233.8	265.2	326.8

Source: Office of the Under Secretary of Defense for Research and Engineering

3.2.3 Impacts

An assessment of the impacts of increased DoD funding on current university research capabilities leads to a conclusion that such increases are necessary, but will be insufficient to restore the nation's full utilization of the university research community. At a time when non-DoD research support is, at best, remaining constant, increased DoD support is more necessary than ever to maintain the universities' responsiveness. However, the interdependency of research programs and the complementarity of federal funding may mean that the defense research capabilities of the university community will be weakened in spite of increases in areas and disciplines directly necessary for national security.

3.3 DOD ASSISTANCE IN MANPOWER TRAINING

3.3.1 Recent and Ongoing Programs

The military Services have traditionally supported the training and education of undergraduates through their Reserve Officer Training Corps (ROTC) programs. (More recent initiatives -- fellowship programs for advanced degree students and apprenticeship programs for high school students -- will be discussed in later paragraphs.) ROTC scholarships are awarded to high school graduates whose academic and personal achievements and intended field of study meet the requirements of the Services. A standard application form is issued, and the application and selection process is similar to that of the Service academies.

Currently, only the Navy and Air Force control the percentage of awards to science or engineering fields of study, the Navy requiring 80%, the Air Force 70%, of scholarship holders to enroll in science or engineering curricula. Navy and Air Force ROTC scholarship holders who switch their major to non-science/engineering studies lose their awards. The Army has no such stipulation, but is under some pressure from OMB to align its policy with that of the others.

The Services maintain ROTC "units" or "corps" at universities throughout the country. Excluding cross-enrollment programs, whereby students from one institution participate in ROTC units at another, the Air Force monitors 144, the Navy 56, and the Army 280 units. As shown in Table 3-5, these units comprise 21,000 students in FY 1982, the same number as in FY 1981. The Army requested and was authorized 12,000 positions, of which only 8,500 have been funded. A supplemental appropriation bill will be required to fund the additional 3,500 scholarships.

TABLE 3-5

ROTC SCHOLARSHIPS

	FY 81	FY 82	FY 83
AIR FORCE	6,500	6,500	9,000 (requested)
NAVY	6,000	6,000	8,000 (requested)
ARMY	8,500	8,500 (12,000 authorized)	To be determined

In recognition of their shortages in science and engineering manpower, all the Services wish to increase funding of the well-known, highly-visible ROTC program. The Air Force has requested 9,000 scholarships for FY 1983 (up 38%) and the Navy 8,000 (up 33%). The Army, having been thwarted in its expansion program in FY 1982, has not yet fixed its ROTC objective.

The Services are now beginning to fund advanced degree training through fellowship and educational support awards so that advanced degree holders who are capable of performing the needed basic research can become familiar with the research needs and objectives of the military. The existing fellowship plans are summarized in Table 3-6 for the three Services. In today's economic climate, stipends of $15,000 to $20,000 a year are judged to be barely adequate to offer competitive alternatives to employment.

TABLE 3-6

FELLOWSHIP AND EDUCATIONAL SUPPORT

	FY 81	FY 82	FY 83
AIR FORCE	$750,000	$750,000 (50 fellows)	Up to $1,000,000
NAVY	--	$800,000 to $1,000,000 (40 to 50 fellows)	$800,000 to $1,000,000 (40 to 50 fellows)
ARMY	--	$500,000 (25 fellows)	To be determined

The Air Force hopes to raise support for this program to $1 million in FY 1983 with stipends increased from $15,000 to $20,000. The Air Force also provides educational support through cooperative university/industry programs in specific technical areas:

- Thermionic Engineering and Research Program -- conducted at the University of Utah in cooperation with the microwave tube industry (participants include Hughes Aircraft, Litton, Northrop Corp., Raytheon, Varian Assoc., Teledyne, Watkins-Johnson).

- Advanced Composite Structures Program -- established at Texas A&M University in collaboration with several aircraft companies, including General Dynamics (Convair and Fort Worth Divisions), Grumman, Lockheed, Rockwell International, and Vought Corp.

- Research in Aircraft Technology Program -- Fluids and Structures research at MIT; Combustions and Fluids at Purdue University; and Structures and Dynamics at Texas A&M University. (Corporate sponsors include Pratt/Whitney, GE, Detroit Diesel Allison, AVCO, and Garrett.)

- Manufacturing Sciences Program -- in its developmental stages, this program will be established at three universities, and will have major corporate participation in intelligent robotics, and manufacturing information systems, methodology, and evaluation.

The Navy, through its contract research program, indirectly supports the education and training of advanced degree candidates. A study conducted in FY 1980 shows that the Office of Naval Research today supports an estimated 2,200 graduate students (some partially) through its contract research programs. The ONR Graduate Fellowship Program will initially target its support, through the award of $12,000 to the fellow and $8,000 to the university, to students in electrical engineering, computer sciences, naval architecture, applied physics, materials sciences, and mechanical and aerospace engineering. Additional fellowship awards are anticipated in FY 1983 and FY 1984 until a base group of 120 fellows is reached. New areas may be targeted for future support.

The Army fellowship program would grant stipends of $12,000 to $15,000 to the fellow with an additional $5,000 awarded to the university. Initial plans call for targeting support in the areas of computer sciences, vertical lift technology, and advanced materials.

Two new national programs to educate and train scientists and engineers in disciplines necessary for national security have been announced recently:

- The Defense Communications Agency will innaugurate the National Science Center for Communications and Electronics at Fort Gordon, GA. The Center will be built and operated with industry funds privately solicited outside the military; more than 100 communications and electronics companies have expressed support for the effort (contributions are in hand from Rockwell International and United Technologies). The Center's principal goal will be to work with industry to develop education and training courses for the nation's secondary schools, colleges, and universities willing to participate.

- The Defense Advanced Research Projects Agency and the Office of Naval Research will support an Artificial Intelligence Laboratory at M.I.T., which will be immediately concerned with design of robotic hardware and robotic programming languages. Among other efforts, the Laboratory will begin publication of a new journal, the International Journal of Robotics Research.

In July 1981, the Department of Defense established a science and engineering apprenticeship program for high school students to stimulate broader interests among high school students in science and engineering careers and to establish individual working relationships among students and active researchers. The program is executed by individual DoD laboratories and by the scientific officers responsible for the Army, Navy, and Air Force research programs. The minimum age limit for the apprenticeship program was relaxed by the Office of Personnel Management to allow employment of high school freshman and sophomores aged 14 and 15 years. DoD sponsors of apprentices are particularly encouraged to refer promising graduates of the apprenticeship program to other DoD laboratories in the communities where the student intends to attend college. If successful, these programs and referrals will direct student scientists/engineers toward defense-related research and issues, and perhaps, ultimate employment by the Department of Defense or its contractors.

3.3.2 Impacts

In view of the urgent and direct need of the Department of Defense for skilled scientists and engineers now and in the near-term future, it is apparent that the impacts of the graduate and undergraduate training assistance programs will be inadequate to furnish the requisite manpower. In 1981, some 229,000 scientists and engineers were employed in defense-related work, and the three Services were supporting 21,050 students (only 50 of them being graduate students) with uncertain levels of commitment to pursuing careers in defense-related research, either as civilians or military.

It is clear that DoD must provide direct manpower training assistance to the universities. Equally important, however, is the indirect support provided to the universities to create an environment in which more scientists and engineers are better educated. Among the items of indirect assistance that the universities have been shown to desperately need that DoD should provide:

- Support for purchase, operation, and maintenance of scientific equipment for teaching and research.
- Support for modernization and construction of research and teaching facilities.
- Arrangements for research and teaching faculty exchange with DoD laboratories.

Regardless of how created, a larger student population in science and engineering will ultimately benefit the Department of Defense. Just as enrollment in graduate school is considered as an alternative to industrial employment, so can employment in defense-related research be considered as an alternative to non-defense work. The manpower situation is a self-correcting one, given enough time for the cycle to complete itself. Currently, undergraduate enrollments in science and engineering are up because of highly rewarding salaries in industry so that graduate schools and government laboratories are not attractive options. As demand pulls up the output of baccalaureates, increasing competition for jobs and decreasing salaries may make graduate school and government laboratory employment alternatives much more acceptable. Until that time, however, DoD must create and promote attractive incentives to encourage talented scientists and engineers to become involved in defense-related research.

3.4 DOD CONTRACTING PROCEDURES

3.4.1 Background

The Department of Defense funds university research programs through both contract and grant mechanisms. The choice of which mechanism to use when funding university research is largely a matter of Service philosophy and approach, since both have been successful in supporting university research. Within the Department of Defense, the Office of Naval Research has traditionally procured research services through contracting, whereas the Air Force Office of Scientific Research favors grant support to universities wherever possible. Regulations governing the acquisition of research services through contracting are codified in the Defense Acquisition Regulations (DARs) and principles for the Department's grant activities are contained in various OMB circulars.

Government-wide guidance related to the acquisition of research services from universities is contained in OMB Circulars A-21, "Cost Principles for Educational Institutions," and A-110, "Standard Administrative Requirements for Grants to Universities, Hospitals, and Non-Profit Organizations," the former covering both grants and contracts, the latter grants and cooperative agreements. The provisions of OMB Circular A-21 covering universities has been incorporated into the DARs as Part 15.3.

All universities come under the cognizance of either the Department of Defense or the Department of Health and Human Services for the negotiation of overhead rates, which determine reimbursements to the universities for allowable indirect costs. Within DoD, which has cognizance of over 40 universities, the Office of Naval Research has the authority to negotiate overhead rates and the Defense Contract Audit Agency the responsibility of auditing. All federal agencies' funding programs are bound by the rate negotiated by the Office of Naval Research for the forthcoming year, just as DoD is bound by rates negotiated by DHHS at a university over which it has cognizance.

3.4.2 Current Initiatives

Throughout the Federal Government, efforts are underway to simplify acquisition regulations and speed up the acquisition process, from source selection to final payment, regardless of whether the contractor/grantee is a university. However, universities and colleges have posed special problems for the application of government procurement regulations, one of the major ones being the time and effort reporting requirements imposed by OMB Circular A-21 in 1979. Recently, however, proposed revisions of this Circular to resolve this specific problem were published in the Federal Register (January 7, 1982) for a 60-day comment period.

Specifically, within DoD, the two-year test of the Short Form Research Contract (SFRC) has been judged to be a significant initiative for simplifying procurement of university research. This form is specifically designed to aid in processing and evaluating unsolicited proposals from universities and non-profit organizations so that awards can be made expeditiously.

CHAPTER 4

EXPORT CONTROL AND THE UNIVERSITIES

4.0 EXPORT CONTROL AND THE UNIVERSITIES

4.1 INTRODUCTION

Control of exports, including technical data, is centered in two Departments of the U.S. Government, State (which exercises control of military hardware and technology) and Commerce (which has cognizance of commercial commodity control and dual-use technology).

The State Department, under Section 414 of the National Security Act of 1954, 22 U.S.C. §2778, has issued regulations restricting the "export" by "oral, visual, or documentary" means of certain information, data, and equipment to foreign nationals. These restrictions, known as the International Trade in Arms Regulations (ITAR), rely on the following definition of "export": "Transfer of data and information to, inter alia, foreign nationals within the U.S."

The Export Administration Act (EAA) of 1979 provides authority to regulate exports, to improve the efficiency of export regulation, and to minimize interference with the ability to engage in commerce. In accordance with the Act, the Secretary of Commerce maintains, as part of the Commodity Control List, a list of all goods and technologies subject to export controls, while the Secretary of Defense bears primary responsibility for developing a list of militarily critical technologies, with emphasis on manufacturing know-how, keystone manufacturing equipment, and goods accompanied by sophisticated operation or maintenance know-how. A list of militarily critical technologies was developed and published in the Federal Register on 1 October 1980 as required. The 1 October 1980 list has been updated and the revision is expected to be published very soon.

The shift in emphasis from product control to control of technology (specific products, equipment, and arrays of know-how) has complicated DoD's relationship with the universities since a considerable amount of relevant high technology know-how exists, not only in those industrial firms where the know-how is applied, but also in the universities. A basic tension therefore exists between the requirements of national defense and the need for universities to remain relatively free in their pursuit and dissemination of knowledge.

Industry is driven by goals and motivations quite different than those found in the university, and proprietary restraints act to inhibit the flow of the really important "know-how." In academia, on the other hand, prestige and recognition are attained by being the first to publish a new idea or concept. It is, therefore, crucial that DoD be sensitive to these differences in its pursuit of the control of technologies that are critical in a military sense.

4.2 CURRENT TRENDS

Until recently, the conduct of research in the universities has not caused a significant problem with respect to the handling of sensitive defense information. Most research, even that which has been funded by DoD, is unclassified research. Classified research, on the other hand, is conducted in off-campus institutions (e.g., Lawrence Livermore Laboratory) which, although affiliated with a university, are nonetheless separate enough so that strict security procedures can be employed.

More recently the situation has been complicated by the following factors and trends.

- Changing Nature of Military Technology: Military power is now highly dependent on advanced commercial technology. To further complicate matters, much of the technology that is now useful from a military point of view is also useful in the commercial sector (computers, fiber optics, etc.). Before, research on military-specific technology was somewhat contained in government and industry laboratories and on a selected number of university campuses. Now, with the pervasiveness of high technology throughout military systems, the balance has shifted. With few exceptions, the development of high technology, whatever the source, has military impact.

- Changing Interests of University Researchers: Universities have entered a new era in which applied research in certain fields is receiving pronounced attention. For example, in genetic engineering, high technology companies are being spun off from the universities to conduct proprietary applied research and commercialize the results.

- Emerging Concept of Militarily Critical Technology: The DoD has spent a great deal of time and effort defining what technologies are important, militarily, and what transfer of information or "know-how" would substantially benefit potential adversaries. The Militarily Critical Technologies List (MCTL) is more general than either ITAR or Export Administration Regulations (EAR) in terms of technology know-how and is more oriented toward manufacturing processes -- in the words of the MCTL, "arrays of know-how." Although the list attempts to define and delimit areas of technology, it contains over 620 technology titles with literally thousands of critical elements specified under those titles.

Except for a few academic consultants to DoD, the academic community has little knowledge or appreciation of the struggle within DoD to better define what information, technologies, and critical elements are important militarily and should be subject to some form of review and ultimately of control. Except for the publication of the MCTL titles in the Federal Register on October 1, 1981, there has been little guidance to the academic community on what technologies are considered sensitive and why they should be guarded. The detailed version of the MCTL, which would supply much of this information, is classified. This has led to some consternation on the part of the academic community, since the MCTL titles interpreted broadly could cover a breadth of technology not intended by DoD to be subject to controls.

DoD is caught in a dilemma. If it vigorously attempts to regulate the flow of scientific information in the scientific community, it could jeopardize the strength and vitality of the very community it is seeking to revitalize for the sake of national defense. On the other hand, if DoD abandons any attempt at regulation in the university context, it could seriously compromise and, in certain cases, totally undercut other efforts to control the out-flow of militarily critical technology.

The middle ground is a difficult one to establish. This Task Force has attempted, if not to solve the problem, to at least lay a framework for solving the issue by means both practicable and, it is hoped, acceptable to the academic community. A dialogue with the universities has already begun over the transfer of non-classified but nonetheless sensitive information in the Very High Speed Integrated Circuit (VHSIC) Program.

4.3 DOD GUIDELINES

The university research that DoD would consider militarily critical is for the most part DoD-funded. DoD targets research funds to those areas of basic research with potential for military application. Other federally-funded research (NASA, NSF, DoE, HHS) could have military potential but the proportion of research in this category would be much smaller than that which is funded by DoD. Non-federally-funded university research with military applicability is an even smaller component of university research.

The problem of controlling the flow of sensitive information may not be as difficult as first perceived. If DoD is funding the research, it is reasonable that DoD could, in turn, monitor for national security purposes the flow of information and technical data emanating from the research. This regulation is, in fact, already done in certain areas of research performed by DoD, DARPA, and the Military Departments.

The Air Force, for example, has implemented certain procedures for restricting the flow of unclassified technical information which nonetheless falls under the category of information subject to export control. All documents in this category generated by Air Force personnel or under Air Force contracts must carry the following warning:

SUBJECT TO EXPORT CONTROL

This document contains information for manufacturing or using munitions of war. Export of the information contained herein or release to foreign nationals within the United States, without first obtaining an export license, is in violation of the International Traffic in Arms Regulations. Such violation is subject to a penalty of up to 2 years imprisonment and a fine of $100,000 under 22 U.S.C. 2778.

The focal point for control is the DoD contract; the Government negotiates the terms of the release of information with the contractor. The Project Office or Contract Monitor within DoD thus becomes the interpreter of military criticality and the extent to which ITAR or EAR is applicable. The system is voluntary in the sense that the contract does not have to be accepted. If guidelines for release of information are accepted as part of the contract, then there should be little room for misunderstanding later.

It could be argued that restrictions such as these violate the spirit of academic freedom and will curtail the free flow of information required for maintaining a healthy dialogue within the scientific community. This might be true if DoD were seeking to restrict the flow of all scientific information directly or indirectly related to military capability. This, however, is clearly not the case. The Department of Defense is assiduously rejecting any control guidelines that would restrain the development and dissemination of the fruits of basic research.

The situation is similar to that of proprietary information developed in the course of industrially-funded university research. A corporation supporting university research is not concerned if a professor teaches basic science and engineering in the classroom. If, however, in the course of his research under corporate contact the professor made public information which could in essence benefit a competitor, there would be cause for alarm. The information which could help a competitor is, in general, manufacturing or process know-how, not basic science and technology.

The focus of DoD attention for the near future should be toward establishing clear and consistent guidelines for the release of information in DoD-university contracts. This policy should be standardized for all DoD agencies and the Services so that the universities and individual scientists will not have to cope with uncertainties arising from alternate interpretations or diverging opinions from different DoD agencies. DoD, as a first step should set up some mechanism for establishing and implementing a DoD-wide policy.

- DoD could immediately implement an internal process whereby a committee of R&D experts in OSD and the Military Departments could meet in order to work out mutually acceptable terms for reviewing university research contracts. This process must take place with appropriate consultation with the universities.

- DoD should seek the concurrence of State and Commerce in implementing these guidelines where the DoD Project Manager or Contract Monitor negotiates with the university contractor over what information is releasable and what might be subject to ITAR and EAR.

- In the course of the contract work, pre-publication review would allow for a contractor to change or modify the presentation of technical data so that it would be releasable to the public without going through the licensing process. Pre-review could in a sense be DoD's mechanism for interpreting ITAR for the universities and may be less onerous than requiring universities to submit formal license requests to State (ITAR) or Commerce (EAR). It informs the publishers of the Department of Defense position which, because of the advisory and concurring role of the Department, is likely to be adopted by the Office of Munitions Control.

- In practice, a time limit could be imposed such that the investigator would be allowed to publish his results if, after informing the Government, he has not received a response within a designated period (30-60 days).

- Only in those cases where the information is clearly deemed subject to ITAR/EAR would a license be sought. DoD cannot exempt university research from ITAR. There are no provisions for ad hoc exemptions or arrangements to change the ITAR requirements for individuals or groups including the universities.

- The review process could be simplified further if DoD first addressed the most critical and time-urgent technologies and then proceeded to wider coverage.

If such a plan were implemented, the universities would be assured that DoD is not seeking a broad restriction on the flow of scientific information within the university community which would be against DoD's own interest. The effort would be focused and therefore limited since:

- DoD-funded research constitutes only a part of the overall university research budget.

- Within DoD-funded unclassified research, only manufacturing and process-oriented research (as opposed to basic research) are of concern.

- Even with process-oriented research certain information could be released generally to the scientific community after thorough review.

- Even information which could not be released publicly could be circulated within a selected subgroup of the scientific community.

If the review and control process were centered initially around the DoD contract and the relationship between the DoD Contract Monitor and the university contractor, it would greatly simplify the paperwork.

- The university and the individual scientist would know in advance what was expected in terms of information release. The policy could be clearly articulated.

- The export control/release of sensitive information guidelines would simply be an add-on to the existing contract procedures.

- The Departments of State and Commerce would not be flooded with unnecessary license requests from the university sector.

- Those license applications received from the university sector would be more focused and therefore more substantive since they would have already passed through a process of review of the military significance of the data release.

- Judgment as to what is militarily critical would remain with DoD.

- The system could operate with personnel and structures already in place at DoD, State, and Commerce. It might require some additional staffing to assure that the review process is carried out expeditiously, but would not require an extensive expansion on the part of any one of the agencies and/or creation of a new bureaucracy.

Concerning foreign nationals, DoD's primary interest is to exclude foreign students from participating in advanced research specifically related to the development of militarily critical technologies, and particularly to control foreign students from Communist countries from having access to R&D projects funded by the Defense Department. Numerous advances in Soviet military weapon systems are directly traceable to technology transfers that occurred as a result of Soviet and Warsaw Pact student and scientist exchanges and their attendance at international scientific symposia held in the United States.

Certain individuals have suggested that the responsibility for controlling access by foreign nationals to our campuses must be with the State Department and that the control mechanism be the visa. The universities, however, have few mechanisms for controlling the foreign students once they enter the campus, whether or not they are complying with restrictions. Given the decentralized and fluid nature of most campuses, universities are neither structured nor staffed to police the flow of visitors.

For highly sensitive areas of research, DoD could retain its preference that no foreign nationals be assigned to conduct research, but could accommodate other mechanisms of oversight once the likelihood of ITAR-controlled data being developed in certain program elements has been established.

- Principal Investigators could be asked to assign only U.S. citizens or immigrant aliens to program elements assessed as being likely to develop ITAR controlled data; and

- Principal Investigators could be asked to limit participation in the remainder of the program to foreign nationals who have declared that they do not intend to expatriate their acquired knowledge.

4.4 NON-DOD-FUNDED UNIVERSITY RESEARCH

Research not funded by DoD would essentially fall in two categories:

- Federally-funded research by other agencies (NSF, NASA, HHS, DoE, etc.).

- Industry- or internally-funded university research.

Federally-Funded (Non-DoD) Research

DoD should explore with other agencies the use of contract guidelines similar to those used in DoD contracts, to be negotiated with university contractors in a manner similar to that suggested for DoD contracts. The number of contracts so regulated would be much smaller, percentage wise, than DoD contracts. DoD would furnish the other federal agencies a contact person in DoD who would be supportive in the following ways:

- Determine what areas of that agency's business would fall into the realm of ITAR/EAR.

- Help word the guidelines for the initial research contract.

- Help in pre-publication review if this were deemed appropriate, in a manner similar to that outlined for DoD contract research.

- Take the burden of determining military criticality off the shoulder of the NSF, NASA, HHS, DoE Project Manager and make that the responsibility of DoD.

Except for a few cases, it is anticipated that the need and/or urgency to control non-DoD-funded university research is less than that required for DoD-funded research, since the militarily critical areas are fewer in number and the research is usually not as directly linked to process or utilization technology. Thus, it would not seriously endanger national security if non-DoD-funded research guidelines were negotiated and implemented subsequent to a full implementation of the guidelines for DoD-funded research.

An added advantage for such a graduated approach is a practical one. DoD and the universities will have gained some valuable experience in their communication over DoD-sponsored research. Furthermore, the MCTL and its impact on ITAR and EAR will have been more clearly defined. A graduated strategy does not postpone initial talks and contacts with other agencies over this matter, but merely anticipates what sort of time frame would be required in order to implement a full control program.

It is also possible that a peer review mechanism similar to that adopted for cryptography research may be applicable to basic research funded by agencies other than DoD. This method seems to be working well.

Non-Federally-Funded Research

As was pointed out earlier, a significant amount of basic research is funded by sources other than the Federal Government, including industry, foundations, and private individuals. We are unaware whether any of this research or what proportion of this research would fall into the category of militarily critical and/or be subject to control by ITAR/EAR. Since the Federal Government has no contractual ties, the use of the federal contract or grants as a point of control is not feasible. Voluntary controls and peer review may, however, be possible since the university is still subject to ITAR and EAR whether or not research is federally contracted.

DoD would essentially play the same role as previously, i.e., as consultant and advisor as to what is militarily critical and subject to ITAR and EAR. Universities would still be obliged to submit license application if determination is made that research is subject to control, but these instances could be expected to be few in number since the research itself would have already passed through a filter of military criticality as defined by DoD.

Although DoD's role as an advisor would be the same as that constructed for non-DoD federally-funded research, the mode of approach, the persons and institutions involved, and the process itself could be quite different.

DoD could initiate a dialogue with the university community through its organizational representatives (e.g., Association of American Universities) concerning the magnitude of the problem and, if needed, by the structuring of a peer review process for the control of technical information of a sensitive nature which is the result of research not funded by the U.S Government. Peer review could be in the form of ad hoc committees established by discipline, or more formally, by instituting a review committee within the framework of scientific societies (IEEE, AIAA, ACS, etc.).

Through this forum, the DoD could negotiate a satisfactory resolution of three of the more important elements of any control process.

- Determination of Research Subject to Review: DoD, with its considerable experience in defining the MCTL, could relate its concerns to the academic community and attempt to define a mutually acceptable categorization of research areas that would be recognized as militarily critical, but not contractually subject to the review processes previously discussed. These would no doubt include the dual-use technologies which have both high military and high commercial payoff.

- Specific Guidelines for Selected Research Area: DoD could meet with representatives from the university community, including the scientific societies, to discuss what guidelines would be appropriate for a particular discipline. The guidelines already being developed for DoD-sponsored research could be used at least as a starting point for negotiations.

- Pre-Publication Review: From a constitutional point-of-view, this is the most sensitive area and one which DoD should approach with utmost caution. An overly ambitious program of information control could easily end up in the courts. The emphasis here should be on:

    - the voluntary nature of the program,

    - the principle of peer review,

    - some mechanism for appeal if a particular researcher feels that guidelines have been unfairly imposed, and

    - time limit for response. If the Government has not responded in 30-60 days, the investigator can assume there is no problem with publication of the results.

4.5 SUMMARY

In federally-contracted research programs, the contract negotiation process itself could provide a vehicle for educating the university research community of the needs of DoD for restricting information in certain sensitive areas. Even in areas of research where there is no formal government contract relationship, there could be a form of education through osmosis since research guidelines would be, in most cases, available to the public, and since there is already a substantial flow of information between academics.

There may be a few areas of research of high priority where DoD may wish to catalyze some sort of peer review process similar to that undertaken in the field of cryptography. The need for an extensive peer review program is not immediately apparent and the mere publication of clear DoD guidelines may solve the problem.

A key to any voluntary program is communication. Some of the fears within the academic communities could be alleviated if DoD could make public the description, including critical elements, of those technologies which it considers militarily critical. The document that contains these and the justifications for why these technologies are considered critical is classified SECRET. The promulgation of an unclassified version of the MCTL would help immensely.

Table 4-1 shows schematically how DoD could function as a catalyst and advisor and, in certain cases, an arbitrator in a framework where ITAR/EAR is the legislative umbrella. The plan is structured to utilize existing personnel and avoid the creation of a new bureaucracy. It can be accomplished with little or no additional legislation since it represents only one interpretation of current law and/or the extension of current practice. It is staged in phases that allow DoD to control its own contracts first (Stage I), and then extend to other areas (Stages II and III), with the benefit of the experience derived in Stage I.

TABLE 4-1

A PHASED PROGRAM TO DEVELOP GUIDELINES

FOR RESEARCH SUBJECT TO ITAR/EAR COVERAGE

	PHASE I	PHASE II	PHASE III
	DoD Funded Research	Non-DoD, Federally-Funded Research	Industry/University and Internally Funded Research
Guidelines for dissemination of technical information	• Written into all contracts	• Written into some contracts as deemed appropriate by inter-agency task force (to be instituted)	• Used as needed in peer review process
Implementation	• Immediate set-up DoD-Service wide task force to formulate department-wide policy. • Coordinate policy with State/Commerce	• Initiate Dialogue with all other Federal Agencies concerning extent and specifics of contract coverage • Implementation of guideline coverage could begin after that of Stage I	• Initiate dialogue with university representatives and science societies about extent of problem and possible peer review structure • Highlight only areas which are clearly not covered in Stage I and III • May not have to be implemented
DoD Involvement	• DoD primary actor	• DoD initiates process and furnishes contact point for aid in implementing guidelines, contracts, etc.	• DoD catalyzes a process and plays advisor role only in peer review

CHAPTER 5

FINDINGS

5.0 FINDINGS

GENERAL

There is a serious national problem in the declining ability of our academic institutions to educate scientists and engineers in the numbers needed to maintain a strong national technology base.

- Mathematics and science requirements have been diluted in secondary school curricula. Coupled with inadequate curriculum and career counseling, this causes many students to forfeit science and engineering careers. The near absence of requirements for physics, chemistry, second-year algebra, or trigonometry in high school makes it difficult to initiate college-level programs in science and engineering.

- The U.S. lags far behind the western democracies and Japan, no less the Soviet Union, in general science, in mathematics, and in engineering education. This trend is having clear impact in the rapid advancement of foreign industries to the point where they rival the U.S. in certain areas of high technology. The long-term impact on the military balance should not be underestimated.

Universities have expressed a real interest in and are capable of assisting the national defense by performing DoD-sponsored research and training the manpower required for defense.

- The mood of the nation has changed since the Vietnam era. The DoD/university relationship was no doubt damaged by student reaction over the conduct of the war in Vietnam, but the serious decline in DoD research funding and the introduction of the Mansfield Amendment (calling for a "direct and apparent relationship" of research to a military function or operation) were other important factors.

- The Association of American Universities maintains that, with appropriate and sufficient support, "research universities can promise the following: (1) that the highest quality research will continue to be conducted in university laboratories; (2) that the nation will have sufficient numbers of highly trained scientists, engineers, and other specialists to meet the defense-related needs of industry, government, and the universities; (3) and that research personnel will be better aware of defense problems, and those able to help with innovative ideas will be encouraged to do so."*

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* Report of the Task Force on Defense Requirements and University Preparedness to the Committee on Science and Research of the Association of American Universities, October 1981.

FUNDING FOR RESEARCH, EQUIPMENT, AND FACILITIES

Although basic research funding, as a percentage of the technology base funding, has remained relatively constant, DoD funding of research has declined over the long term and will require multi-year increments of real growth to return it to its former level of support.

- In constant FY72 dollars, DoD support of research in FY81 was only 62% of the FY65 support level, even though funding has increased almost 28% from its low point of $244 million in FY75.

DoD must be concerned about the impact on the technology base in the universities caused by budget cuts and organizational changes in non-defense agencies and departments.

- National Science Foundation funding is perceived to be a catalyst for complementary funding from both industry and government. Budget uncertainties have caused great concern for basic research in mathematics, physics, and engineering, not to mention the life and social sciences. NSF's far-reaching role in science and engineering clearly would influence the fate of areas of DoD interest should NSF budgets fail to maintain appropriate funding levels.

- The budget constraints and organizational uncertainties in the Department of Energy affect, among others, programs in material science, energy storage, fusion, and high energy physics that are of interest to DoD.

- NASA, once very influential in university research in a variety of high technology areas and in manpower training through fellowships and traineeships, is hard pressed to maintain these programs.

Industrial support of R&D in universities and colleges has traditionally been low level, but the university/industry relationship is healthy.

- Industry has contributed 3% to 4% of university R&D funds, compared to the Federal Government's contribution of 66% to 68% (including DoD's 13%).

- University faculty and graduate students have traditionally maintained consulting and business relationships with industry, a portion of these being with defense-related industries.

- Recent tax legislation offers incentives in the form of tax credits (up to 25% of R&D salaries) to industries contracting for R&D with universities and other non-profit institutions. It is too early to assess the impact of this incentive in encouraging additional industry sponsorship of R&D in the universities.

Critical shortages in university equipment and facilities have developed in recent years.

- Equipment obsolescence and increasing replacement costs have handicapped university efforts to maintain a research and development hardware capability. University computing equipment and facilities, laboratory equipment (for both research and teaching), test equipment and instrumentation could all be upgraded with a rapid payback. A declining space exploration program, for example, has left university research laboratories with aging equipment and no replacement prospects.

MANPOWER AND TRAINING

Skilled scientists and engineers in certain fields are not being educated and trained in adequate numbers to meet the combined needs of government and industry.

- Shortages of computer scientists, and chemical, electrical petroleum, industrial, and oceanographic engineers have been identified.

- Engineering doctorate degrees fell 27% from a 1972 peak to 2,751 in 1980. DoD is experiencing difficulties in attracting and retaining qualified scientists and engineers to its laboratories.

- A major impediment to meeting Government requirements, although not the only one, is low salary rates for GS-5 and GS-7 entry levels. The salary differential, however, for entry level graduate degree holders is not as severe. DoD estimates that it currently has 5,000 unfilled civilian and military openings in the physical sciences and engineering.

For a variety of reasons, our universities are training fewer PhDs, and fewer Americans are entering graduate school.

- Market forces now play a significant role. The differential between the salary offered a PhD and that offered a baccalaurate is not great enough to attract greater numbers of U.S. citizens into graduate programs.

- The flow of U.S. citizens into graduate schools can be expected to increase eventually as a result of the current burgeoning enrollments in undergraduate engineering programs. Advanced degree training can be expected to become an attractive alternative to industrial employment as graduate assistantship/fellowship stipends increase and industrial salaries are constrained by an increased supply of engineers.

Engineering schools now have a sufficient number of entrants but are hampered by the shortage of faculty.

- The inability to compete with industry either for entry-level faculty PhDs or PhD candidate feedstock has produced a staffing crisis in our universities. The nations's 286 schools of engineering report over 2,000 vacancies in the budgeted faculty plan. Nationwide, over 200 vacancies exist in computer science faculties. Although undergraduate enrollments have swelled to record levels, graduate enrollments and degrees conferred have fallen dramatically. Engineering doctorate degrees, for example, fell 27% from the 1972 peak. Remedial action is clearly required.

On the positive side, DoD is actively involved in stimulating science and engineering careers oriented toward defense-related research.

- An apprenticeship program was recently established to encourage high school students to work with components of DoD in research areas of mutual interest.
- The ROTC program is being expanded by the three Services.
- The three Services are instituting and expanding fellowship and educational support programs to familiarize science and engineering graduate students with defense research problems.

EXPORT CONTROL

Certain specific areas of university research, especially those conducted under DoD contract, are sensitive from an export control point-of-view. With the help of the universities, DoD must formulate clear and concise guidelines for the dissemination of technical information.

- DoD cannot exempt the universities from the legislated restrictions of International Trade in Arms Regulations (ITAR) and the Export Administration Regulations (EAR).
- Interpretation of ITAR/EAR for university researchers is required and consistent guidelines should be established.
- Sensitive, non-classified information should be subject to limitations on its distribution. Any plan to accomplish this must consider the special requirements for basic research.

The presence of foreign nationals in university science and engineering programs poses special problems with respect to defense-related research.

- In 1979, about 20% of all science and engineering doctorates awarded in the U.S. were to foreign citizens. In engineering, almost one-half (46.3%) of all doctorate recipients were foreign. This high percentage is due to the fact that a number of foreign citizens in graduate schools has leveled off, while the number of U.S. citizens receiving science and engineering doctorates has fallen.

- Although a tribute to the quality of U.S. education, the presence of a large component of foreign science and engineering students in the nation's universities and their involvement in university research pose special problems in the generation and transfer of militarily critical information. This is particularly true in the case of students from the Soviet Union and Eastern Bloc countries.

OTHER CONCERNS

DoD has improved many procurement practices to accommodate university research.

- The Short Form Research Contract (SFRC), designed to handle unsolicited proposals from universities, is nearing the end of a two-year test period, during which the time required to process such proposals was significantly reduced.

There is renewed recognition by DoD that there are shortages of qualified personnel in areas such as languages that will impact intelligence and foreign policy activities of the U.S. Government, including defense.

- The Department of Defense clearly is one of the government agencies most dependent on knowledge about other countries and their peoples. The foreign language and area studies programs of the nation's universities have been in a state of gradual decline and may not be adequate to support national needs.

The U.S. is not always able to capitalize on the knowledge and skills acquired by foreign citizens who are trained in U.S. graduate schools.

- Much anecdotal information exists to support the observation that many foreign doctorate recipients are forced to leave the country involuntarily, because of immigration laws, after receiving their training at U.S. institutions.

CHAPTER 6

RECOMMENDATIONS

6.0 RECOMMENDATIONS

To ensure the continuing strength and vitality of the research and training capabilities of universities, the Task Force recommends the following actions be taken by the Department of Defense.

FUNDING FOR RESEARCH, EQUIPMENT, AND FACILITIES

- The USDRE give guidance and support to the Services to increase 6.1 Research funding to universities, over and above any special provisions for instrumentation, to accommodate real sustained growth.
- Within the overall increase in funding for all university research, target critical needs for special attention.
- The USDRE direct the Defense Acquisition Regulations Committee to revise current procurement policies and regulations to encourage additional Independent Research and Development (IR&D) for industry support of university research.
- The USDRE direct Services to provide funding to the universities for a sustained period, over and above 6.1 Research funding, specifically aimed at improving university equipment and facilities.
- Continue Tri-Service funding and coordination on large capital budget items for DoD programs in connection with ongoing research contracts.

MANPOWER AND TRAINING

- The USDRE authorize each of the Services to award additional science and engineering graduate fellowships and educational support annually similar to those contained in the FY 1983 budget (40-50 new research fellowships at the $15,000 level). Award fellowships to U.S. citizens only.
- Continue to support graduate student assistantships in defense-related research programs within the targeted discipline areas at levels consistent with the prevailing economic climate and university compensation policy.
- The Secretary of Defense direct the Services to increase funding of existing ROTC programs, broadening their coverage and scope, if necessary, to attract outstanding students to military careers.

EXPORT CONTROL

- The USDRE initiate a process whereby the research and development experts in OSD and the Miltary Departments, in consultation with the universities, would develop mutually acceptable terms for reviewing university research contracts.

- For the dissemination of technical information in DoD-funded university research, draft clear, concise guidelines that are not overly restrictive and that would not inhibit the legitimate flow of scientific information.

- After implementing guidelines for DoD-funded research, negotiate similar guidelines for other federally-funded research and, if necessary, non-federally-funded research. Care must be exercised to include only research potentially subject to the International Trade in Arms Regulations (ITAR) or the Export Administration Regulations (EAR).

- Coordinate activities with the Departments of State and Commerce to reduce to a minimum the necessity of university researchers to apply formally to the Government for export licenses.

- The USDRE make available an unclassified version of the Militarily Critical Technologies List (MCTL) as a means of educating the university community about DoD's technology transfer concerns.

OTHER CONCERNS

A DOD Forum for University Concerns

- The USDRE create a forum to allow periodic consultations between senior university representatives and DoD officials on the full range of research-related needs and issues that affect the Department's ties with universities. The Defense Science Board, which already has university representation in its membership, could serve as the mechanism for creating such a forum.

Contracting Procedures

- Continue to simplify acquisition procedures and regulations for procuring basic research from universities. Specifically:

  - Support the Short Form Research Contract (SFRC) now being tested by DoD.

  - Develop standard contractor proposal formats.

  - Eliminate "representations, certifications, and acknowledgements" that are inappropriate for universities.

Foreign Languages and Area Studies

- The Secretary of Defense encourage other agencies to strengthen existing foreign language and area study programs, particularly those authorized under Title VI of the Higher Education Act of 1980. In addition, the Department should assess the consequences for our national security of the weakened university research and training capabilities in these areas, and expand the use of appropriate DoD mechanisms to support work of particular significance to defense needs.

Interagency Coordination

- Continue cooperating with other federal agencies and departments on research funding, fellowship awards, and other support so that the basic science and engineering disciplines with critical needs can be maintained and grow in a stable programmatic environment.

Faculty Involvement

- Continue to promote closer ties and long-term relationships between faculty members in key areas and defense-related projects in DoD laboratories or Federal Contract Research Centers (FCRCs) through consulting agreements or research funding.

- Emphasize the importance of and opportunities available under the Intergovernmental Personnel Act, which permits university/government personnel exchanges for periods of up to two years.

Information

- Continue the present programs of disseminating information about DOD research interests, programs, and facilities to universities and colleges.

- Through a joint effort in government and the private sector (e.g., the National Research Council), encourage the publication of a general catalogue listing fellowships, assistantships, scholarships, and manpower training grants offered by government, industry, foundations, and other institutions connected with the universities.

APPENDIX A

TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

13 OCT 1981

RESEARCH AND ENGINEERING

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Defense Science Board Task Force on University Responsiveness to National Security Requirements

You are requested to form a Task Force to assess the capacity of the national asset represented by the nation's universities to support national security requirements. The relationship between the DoD and many universities eroded during the Vietnam Era. However, the opportunity for strengthening the contribution of universities to national defense is present today. Greater cooperation between universities and the DoD could potentially benefit each.

Your report will provide the response to the House Armed Services Committee's request to conduct a study, similar to the DSB 1980 Summer Study in Industrial Responsiveness, to address university responsiveness to national security requirements. The recent DSB Summer Study on the Technology Base covered a portion of the topics in response to the HASC request. It is anticipated that the pertinent findings and recommendations of this DSB Summer Study would be considered in the preparation of the report of your Task Force.

The Task Force should address the following questions:

1. Is there real university interest in performing classified and unclassified research with clear-cut DoD application and sponsorship? If so, are the conditions under which this research would be performed compatible with national security interests? If not, what steps can be taken (by either DoD or the universities) to improve the situation?

2. What problems are introduced by the high and still increasing numbers of foreign students now enrolled in our science and engineering graduate schools? What, if anything, can DoD do about this impact on: (a) our future DoD supply of high quality technical personnel; and (b) the present conduct of university research on DoD subjects under reasonable security conditions?

3. Is there adequate interaction between the universities and industry in research and development programs of DoD interest? If not, what incentives should DoD provide to increase this interaction?

4. Does the implementation of current export controls on information relating to munitions list technologies restrict research and teaching activities conducted by universities? If it does, what actions should be taken to implement mutually satisfactory measures to accommodate both DoD and university needs?

5. Are the current DoD contracting and grant policies and procedures appropriate for universities? If not, what actions should be taken to change DoD rules?

6. What should be the role of the DoD in supporting basic research vis-a-vis that of the National Science Foundation and other agencies? How and to what extent should DoD support research that will promote science and engineering education?

7. Is the output of trained manpower from undergraduate and graduate schools adequate to meet critical national defense needs in the decade ahead? If not, what steps might be taken to improve the situation.

Additional areas to improve the relationship between DoD and the universities are to be considered provided sufficient time and resources are available to the Task Force.

The Task Force report should be prepared by January 1982. This DSB Task Force will be sponsored by Dr. George P. Millburn, Acting Deputy Under Secretary of Defense for Research and Engineering (Research and Advanced Technology). Dr. Ivan L. Bennett, Jr., New York University, has agreed to serve as Chairman of the Task Force and Dr. Samuel A. Musa, OUSDRE(R&AT), will serve as Executive Secretary. Lt. Col. Jerome A. Atkins, USAF, Military Assistant, will be the DSB Staff point of contact.

APPENDIX B

TASK FORCE MEETING ATTENDEES

The following persons made presentations to the Task Force:

Mr. Anthony Battista	Professional Staff Member, Committee on Armed Services, U.S. House of Representatives
Dr. Edward Bloustein	President, Rutgers, The State University of New Jersey
Dr. Robert Cooper	Assistant Secretary of Defense (Research and Advanced Technology)
Dr. Richard DeLauer	Under Secretary of Defense for Research and Engineering
Dr. Charles E. Falk	National Science Foundation
Mr. Frank Kapper	Office of Under Secretary of Defense for Research and Engineering (International Programs and Trade)
Dr. Robert Sproull	President, University of Rochester
Dr. Jimmie R. Suttle	Assistant Director for Research, Office of the Under Secretary of Defense for Research and Engineering (Research and Advanced Technology)
Mr. Arthur Van Cook	Office of the Under Secretary of Defense (Policy)
Mr. David A. Wilson	University of California

In addition, the following persons attended the Task Force meetings.

LTC Jerome A. Atkins	Office of Under Secretary of Defense for Research and Engineering, Defense Science Board
COL Jim Baker	USAF, Air Force Office of Scientific Research
Dr. Thomas Barlett	Association of American Universities
Joel Barrier	National Science Foundation
Wayne Bert	Office of Secretary of Defense, International Security Policy

Ms. Jean Carney	Office of Under Secretary of Defense for Research and Engineering, Research and Advanced Technology
Mike Cifrino	Office of Secretary of Defense, General Counsel
Dr. John Crowley	Association of American Universities
Arthur E. Fajans	Office of Deputy Under Secretary of Defense for Policy
Joseph Feinstein	Office of Under Secretary of Defense for Research and Engineering, Research and Advanced Technology
Ruth Greenstein	National Science Foundation
Allen W. Himes	USN, Naval Material Command, Laboratory Management Division
Charles D. Hollister	Dean, Woods Hole Oceanographic Institution
MAJ R. W. Kopka	USAF, Air Force Office of Scientific Research
Dr. Bernard A. Kulp	USAF, Air Force Systems Command
Larry W. Lacy	National Science Foundation
R. A. Langworthy	USA, Material, Readiness and Development Command, Technology Planning
Kim McDonald	Chronicle of Higher Education
Dr. George P. Millburn	Office of Deputy Under Secretary of Defense for Research and Engineering
Micah H. Naftalin	National Academy of Science
Herbert Rabin	Office of Assistant Secretary of Navy for Research, Engineering, and Systems
William F. Raub	National Institutes of Health
Richard Reynolds	Defense Advanced Resarch Projects Agency
Dr. Hermann Robl	USA, Army Research Office
Jerald Roschwalb	National Association of State Universities and Land-Grant Colleges

COL D. A. Smith	USAF, Research, Development, and Acquisition
Martin Thibault	Schlossberg-Cassidy and Associates, Inc.
A. W. Trivelpiece	Department of Energy, Office of Energy Research
Johnna VanArsdale	Washington University, St. Louis
Dr. Leo Young	Office of Under Secretary of Defense for Research and Engineering, Research and Advanced Technology
Daniel J. Zaffarano	Council of Graduate Schools, Iowa State

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